Original Article

Postoperative Complications After Extraction of Impacted Mandibular Third Molars: A Clinical Observational Study On Dental Position And Risks

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ABSTRACT

Aim: This study examined the associations between the position of impacted mandibular third molars and postoperative complications, with a focus on pain, swelling, and their associations with proximity to the mandibular canal. **Methods:** A retrospective cohort of 270 patients who underwent surgical extraction of mandibular third molars was analyzed. Preoperative panoramic radiographs were evaluated by three experienced surgeons to classify the tooth position (Winter classification) and proximity to the mandibular canal (Rood and Shehab classification). Postoperative complications (pain, swelling, trismus, paresthesia, hematoma, and hemorrhage) were assessed via standardized questionnaires and clinical records 7 days postoperatively. Data analysis included descriptive statistics and multinomial logistic regression. **Results:** Mesioangular and horizontal impactions were significantly associated with increased postoperative pain and swelling. Logistic regression indicated that the mesioangular position increased the odds of pain by 95% (odds ratio [OR] = 1.95) and swelling by 85% (OR = 1.85). The horizontal impact increased the odds of pain by 2.8 times (OR = 2.8) and swelling by 5.0 times (OR = 5.0). Tooth position was a significant predictor of postoperative complications ($P = 0.007$), whereas proximity to the mandibular canal, patient age, and the mandibular side were not. Root darkening emerged as a notable radiographic finding. **Conclusions:** The position of impacted mandibular third molars, particularly mesioangular and horizontal angulations, significantly influences postoperative pain and swelling. These findings highlight the importance of considering the tooth position in surgical planning to reduce complications. Although panoramic radiography is useful in resource-limited settings, cone-beam computed tomography is advised for complex cases or when vital structures are at risk.

Keywords: *Panoramic radiography, inferior alveolar nerve, third molars, postoperative complications*

Introduction

The extraction of third molars is one of the procedures most commonly performed by dentists.[1,2] Despite its frequency, it is associated with several postoperative complications, such as pain, trismus, edema, nerve

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injuries (involving the lingual and/or inferior alveolar nerves [IANs], resulting in temporary or permanent paresthesia), temporomandibular joint injury, and bleeding and bruising.. These risks are related to factors intrinsic to the patient, such as age, sex, the use of drugs or tobacco, and postoperative care, as well as factors related to the operator, including the experience of the surgeon, the surgical technique used, and the duration of surgery.[3]

The positional variability of third molars, particularly in the mandible, poses an additional challenge. These teeth often have impaction or semi-impaction, being close to important structures, such as the inferior alveolar neurovascular bundle and the lingual nerve.[4] To aid in surgical planning and minimize complications, classification systems have been widely used. The Winter classification[5] evaluates the orientation of the third molar in relation to the second molar, whereas the Rood and Shehab classification[6] considers radiographic signs indicative of the relationship between the tooth and the inferior alveolar canal, including deviation, narrowing or interruption in the mandibular canal, and channel continuity.

Panoramic radiography has demonstrated significant utility in routine clinical assessment, primarily because of its extensive availability, cost-effectiveness, and a relatively low degree of radiation exposure.[7] Despite its widespread use, studies have highlighted its limitations in resolving complex anatomical details, including variations in the mandibular canal trajectory, the presence of accessory canals, and the precise relationship between the roots of impacted third molars and the IAN.[8] These challenges have been underscored by findings that emphasize the diagnostic inadequacy of panoramic imaging in critical surgical planning, particularly when evaluating the risk of nerve injury or assessing root morphology. Nevertheless, in resource-constrained settings, panoramic radiography remains a cornerstone of preoperative assessment, effectively serving as a compromise between accessibility and diagnostic accuracy.[9-11]

In contrast, cone-beam computed tomography (CBCT) has been consistently validated as the superior imaging modality for detailed anatomical evaluations. Research has corroborated its unparalleled ability to visualize structures without overlaps, enhancing both diagnostic confidence and intraoperative safety.[9] Moreover, studies have shown that CBCT significantly reduces the incidence of postoperative complications, such as nerve damage and surgical site morbidity, by providing precise spatial relationships between impacted teeth and adjacent structures. However, the financial and logistical barriers to CBCT implementation, coupled with concerns over cumulative radiation exposure, have limited its adoption in routine practice, particularly in low-resource settings.[12-15]

This study aims to bridge the gap between these imaging modalities by investigating the predictive value of panoramic radiographic findings, particularly in the absence of CBCT. By reflecting the realities of global clinical practice, this research seeks to provide insights into achieving a balanced approach that prioritizes cost efficiency, accessibility, diagnostic accuracy, and patient safety.

Materials and Methods

This observational clinical study was approved by the Ethics Committee of the institution under number 4.354.361. All participants signed an informed consent form, which was prepared in accordance with the updated guidelines of the Guideline for Good Clinical Practice E6 (R2). The study strictly followed the ethical principles established in the guidelines of the Declaration of Helsinki, guaranteeing the privacy and rights of participants at all stages of the study.

Sample selection

The sample size was determined on the basis of previous studies with similar methodologies[13-15] and on a statistical analysis of the sample size considering a significance level of 5% and a statistical power of 80% ($\beta = 0.20$). And a moderate effect size (Cohen's f = 0.25) was used in the jpower module of Jamovi software (version 2.4.14; Sydney, Australia).

The calculations indicated a minimum requirement of 240 samples for the analysis. Thus, 270 panoramic radiographs and medical records of individuals who underwent extraction of lower third molars between 2017 and 2020 at a public reference center for oral and maxillofacial surgery were included.

All surgeries were performed by the same professional via surgical techniques adapted to the position of the tooth, including the decision to perform osteotomy and odontosection. The anesthetic used was 2% lidocaine with epinephrine (1:100,000). Preoperative drug therapy was prescribed for patients with cardiovascular disorders. Postoperatively, patients received a combination of antibiotics (amoxicillin 500 mg), anti-inflammatory drugs (typically 100 mg), and corticosteroids (dexamethasone 4 mg) to minimize complications and promote positive recovery.

Panoramic radiography was chosen as the imaging method because of its wide availability in the medical records of the study site database, its lower cost, the low purchasing power of the population, and the difficulty of accessing other imaging techniques. All panoramic images were obtained via OP200 equipment (Instrumentarium, Tuusula, Finland), following the manufacturer's recommendations, with the following parameters: 120 kVp; 5 mA; and an acquisition time of 40 s.

The inclusion criteria for the images were as follows: patients aged between 15 and 50 years who underwent surgical removal of at least one lower third molar, the absence of endodontic treatment for the tooth in question, the absence of pathological root resorption, and the presence of complete root formation.

The exclusion criteria were medical records of patients with a history of mandibular fractures; pathological changes related to the lower third molars; presence of metallic artifacts; systemic diseases that alter the perception of pain (such as fibromyalgia); smoking; diabetes; chronic use of corticosteroids or drugs similar to those administered in the study; or drug interactions that could interfere with the analysis.

Evaluation parameters

Three main parameters were evaluated: tooth position according to the Winter classification, which covers seven levels: vertical, mesiangular, distoangular, horizontal, vestibular–angular, lingual–angular, and inversion; proximity of the tooth to the mandibular canal, according to the Rood and Shehab classification; and eight radiographic levels: root darkening, root deflection, root narrowing, darkening of the root apex and bifid root, interruption of the radiopaque line of the canal, canal deviation, and narrowing of the channel. Postoperative complications were recorded via a questionnaire administered to the patients 7 days after the surgical procedure.

The questionnaires included standardized dichotomous questions (yes/no) to assess the presence of pain, swelling, trismus, paresthesia, hematoma, and excessive bleeding or hemorrhage. For each variable, specific scales and criteria were employed to ensure precise evaluation: Pain: patients were asked, "Did you experience pain after the procedure?" If yes, they were instructed to rate the intensity using either a visual analog scale, ranging from 0 (no pain) to 10 (worst pain imaginable), or a numeric rating scale with clearly defined anchors: 0 (no pain), 5 (moderate pain), and 10 (worst possible pain). Swelling: swelling was assessed via a dual approach: objective measurement: facial discrepancies, such as intergonial distance or submandibular region circumference, were measured and compared with preoperative baseline values. Likert scale: patients rated swelling severity on a 5-point scale, where 1 = no swelling, 3 = moderate swelling, and 5 = severe swelling, with visible facial asymmetry. Trismus: patients were asked, "Did you experience difficulty opening your mouth?" Maximum interincisal opening was measured in millimeters, categorized as normal (>35 mm), moderate limitation (25–35 mm), or severe limitation (<25 mm). Additionally, the Helkimo Index was used for subjective assessment, categorizing jaw mobility from no limitation to severe limitation. Paresthesia: patients were asked, "Did you experience numbness or tingling in the lips, chin, or tongue?" If yes, the tactile response was evaluated via the Semmes–Weinstein monofilament scale, which grades sensation from 1 (normal) to 5 (complete loss of sensation). Hematoma: patients were asked, "Did you notice bruising in the surgical area?" Hematoma severity was categorized as mild (localized discoloration), moderate (bruising extending beyond the immediate surgical area), or severe (extensive discoloration affecting surrounding tissues). Excessive bleeding or hemorrhage: patients were asked, "Did you experience bleeding after the procedure?" Responses were categorized via the WHO Bleeding Assessment Tool: 0: no bleeding; 1: mild bleeding (controlled at home); 2: moderate bleeding (requiring local intervention); 3: severe bleeding (requiring professional assistance); 4: life-threatening hemorrhage

In addition to these assessments, medical records provided supplementary data on demographic characteristics (e.g., age, sex, and ethnicity), medical history, surgical details (e.g., procedure duration and type of anesthesia), prescribed medications, comorbidities, and prior surgical complications. This comprehensive methodology ensures a detailed and reliable evaluation of postoperative outcomes, integrating both objective measurements and patient-reported experiences.

Image analysis methodology

The panoramic images were analyzed by a single experienced radiologist with more than 10 years of experience in radiographic interpretation. To ensure the reproducibility and reliability of the evaluations, an intraclass correlation test (ICC) was performed on the basis of a pilot analysis of 50 images evaluated twice by the same observer, with an interval of 2 weeks between evaluations. The value obtained was excellent (ICC = 0.94; 95% CI = 0.91–0.96), indicating high intraobserver consistency, and the analysis was performed using the seolmatrix module of the Jamovi software (version 2.4.14; Sydney, Australia).

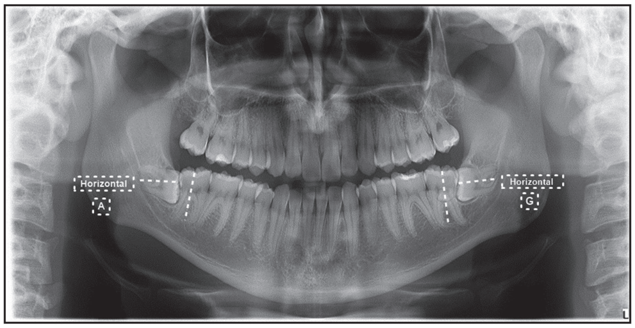

Figure 1: Winter classification for elements 38 and 48: Horizontal (4); Rood and Shehab classification for element 48: root darkening (A) and element 38: interruption in the white line of the canal (G)

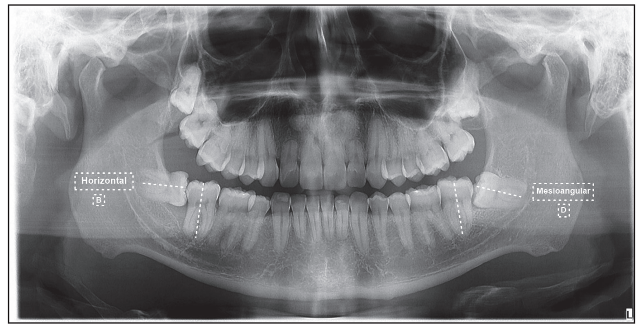

Figure 4: Winter classification - element 48: horizontal (4) and element 38: mesioangular (2); Rood and Shehab Classification - element 48: root deviation (B) and element 38: bifid root apex (D)

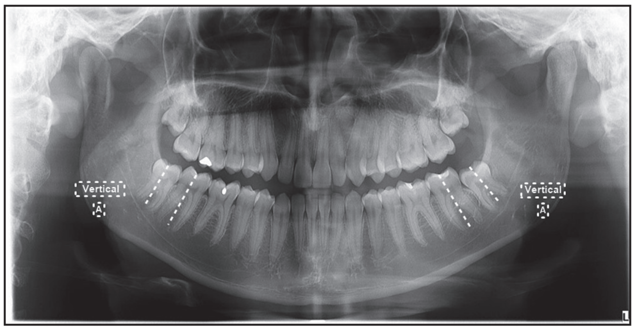

Figure 2: Winter classification for elements 38 and 48: vertical (1); Rood and Shehab classification for elements 38 and 48: root darkening (A)

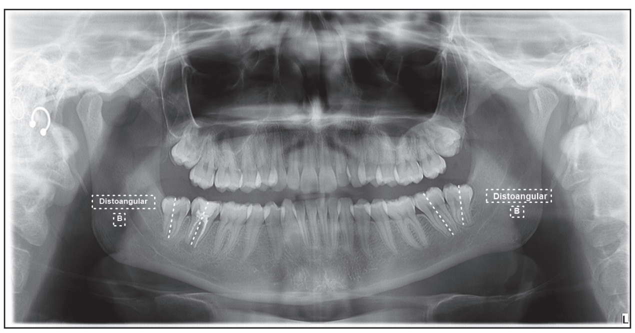

Figure 3: Winter classification for elements 38 and 48: distoangular (3); Rood and Shehab classification for elements 38 and 48: root deviation (B)

Images were examined on a 19.5-inch LG monitor with 1366 × 768 (HD) resolution (LG, Brazil, Taubaté) in a quiet room with controlled ambient light. Brightness, contrast, and zoom adjustment tools were used to optimize the analysis of the images [Figures 1–4]. To mitigate observational bias, the observer was blinded to the clinical and demographic data of the patients, as well as to the outcomes being investigated in the present study, ensuring that evaluations were based solely on the radiographic images. The images were analyzed in a randomized order to avoid systematic errors related to sequence effects. Furthermore, the ambient conditions were standardized to minimize external influences on image interpretation.

Statistical analysis

The data were tabulated in an Excel spreadsheet (Microsoft 365) and subjected to descriptive analysis for the exposure factors related to the categories studied. Next, multinomial logistic regression was performed to correlate postoperative complications with age, side of the mandible, proximity of the element to the mandibular canal, and tooth position. The significance level adopted was 5%, and the analyses were conducted via Jamovi software (version 2.4.14; Sydney, Australia).

Results

Table 1 presents the descriptive analysis with frequency distributions for sample characterization.

According to the data on postoperative complications, the position of the teeth plays a relevant role in the occurrence of different symptoms. The vertical position of the teeth was associated with a greater frequency of swelling (17.6%) and the absence of symptoms (15.3%). With respect to the other tooth positions, the mesioangular position presented a high occurrence of swelling (9%) and pain (4.3%). On the other hand, the distoangular position presented a lower frequency of complications, with pain (2.7%) being the most frequent symptom.

In addition, combinations of symptoms, such as pain and swelling, were observed in various tooth positions; these symptoms were present in 6.3% of the patients with mesioangular teeth and in 4% of the patients with horizontal teeth. More complex combinations, such as pain, swelling, and paresthesia, are rare, with a low incidence in all positions. In general, the absence of symptoms was more common in vertical teeth (15.3%), followed by mesioangular teeth (5%) and distoangular teeth (0.3%), suggesting that the position of the tooth

Table 1: Distribution and frequencies

	Account	% of total	Cumulative %
SIDE			
Left	155	51.5%	51.5%
Right	146	48.5%	100.0%
ESM			
<17	6	3.6%	51.5%
≥17	159	96.4%	100.0%
Proximity tooth mandibular canal			
Channel_ deviation	5	1.7%	1.7%
Channel_ narrowing	10	3.3%	5.0%
Interruption_ channel	17	5.6%	10.6%
Root_apex_ bifid_root	45	15.0%	25.6%
Root_ darkening	50	16.6%	42.2%
Root_ deflection	102	33.9%	76.1%
Root_ narrowing	72	23.9%	100.0%
Tooth position			
Distoangular	22	7.3%	7.3%
Horizontal	42	14.0%	21.3%
Mesioangular	86	28.6%	49.8%
Vertical	151	50.2%	100.0%
Postoperative complications			
Hematoma	3	1.0%	1.0%
Pain	52	17.3%	18.3%
Pain hematoma	5	1.7%	19.9%
Pain swelling	47	15.6%	35.5%
Pain swelling bruising	7	2.3%	37.9%
Pain swelling paresthesia	1	0.3%	38.2%
Pain swelling-trismus	5	1.7%	39.9%
Swelling	101	33.6%	73.4%
Swelling-hematoma	14	4.7%	78.1%
Swelling-bleeding	1	0.3%	78.4%
Swelling-trismus	1	0.3%	78.7%
Trismus	1	0.3%	79.1%
No symptoms	63	20.9%	100.0%

directly influences the type and severity of postoperative complications [Table 2].

In likelihood ratio tests, which assess the contribution of each predictor variable, some variables are found to be statistically significant. The variable Tooth_Position was significant ($\chi^2 = 60.2$, df = 36, $P = 0.007$), suggesting that the position of the tooth has a relevant effect on the likelihood of postoperative complications. On the other hand, other variables, such as Age ($\chi^2 = 13.4$, df = 12, $P = 0.343$), Side ($\chi^2 = 12.3$, df = 12, $P = 0.424$) and Proximity to the tooth mandibular canal ($\chi^2 = 74.6$, df = 72, $P = 0.392$), did not present significant results [Table 3].

The analysis of the model coefficients revealed that some variables were strongly associated with the outcome of interest. For example, for the absence of hematoma symptoms, the intercept had an estimate of −70.669 ($P < 0.001$), whereas age ≥ 17 years was significantly associated with a reduced chance of complications (estimate = −62.951, $P < 0.001$). The variable Side (right vs. left) also had a significant effect (estimate = 44.611, $P < 0.001$) on the incidence of hematoma.

Regarding pain, the intercept was positive and significant (estimate = 119.470, $P < 0.001$), indicating a greater probability of pain in the absence of other complications. However, the effect of age ≥ 17 years was again negative and significant (estimate = −119.690, $P < 0.001$), suggesting a lower probability of pain in older patients. The variable Side was not significant for pain ($P = 0.191$), suggesting that the surgery side does not significantly affect this complication.

Finally, the Tooth position variable also presented significant results in some comparisons. For example, the distoangular position of the teeth was associated with an increased chance of postoperative pain. The mesioangular position increased the chance of hematoma (OR = 16.21, 95% CI: 1.74–149.18, $P = 0.023$), whereas the mesioangular position increased the chance of hematoma (OR = 67.15, 95% CI: 2.11–2115.31, $P = 0.035$) [Table 4].

In summary, the model identified significant predictors of postoperative complications, especially tooth position and root darkening, as relevant risk factors. Variables such as age and side of the procedure influence some complications but not consistently. The model fit was moderate, McFadden ($R^2 = 0.237$), and the variables with the greatest impact were properly identified, offering relevant insights for clinical management.

Discussion

The extraction of the third molar is a common dental procedure that carries the risk of complications due to the proximity of vital anatomical structures, particularly the IAN.[13,16-18] Postoperative problems such as swelling, inflammation, bleeding, alveolitis, infection, and sensory disturbances of the IAN disrupt normal healing processes.[19,20] In this study, the null hypothesis was rejected as a significant correlation was identified between the position of the third molars and pain, as well as between the patient's age, tooth position, and edema.[6,21,22]

Additional factors that may contribute to complications include the surgeon's experience, the complexity of the extraction, the duration of the surgery, the degree of intraoperative trauma, the type of anesthesia, and the suturing technique. Notably, all surgeries in this study were performed by an experienced surgeon, and the patients were informed preoperatively about the poential risks.[23,24]

Computed tomography (CT) remains the gold standard in surgical planning for impacted lower third molars, offering high-resolution images that allow detailed visualization of anatomical structures without overlap. However, panoramic radiography continues to be widely used in clinical practice for evaluating the relationship between the mandibular canal and impacted teeth, especially in settings with limited access to advanced imaging technology.[13,25] The main advantage of panoramic radiography lies in its accessibility and relatively low cost, making it a viable alternative in resource-constrained areas. Given these advantages, the integration of machine learning (ML) models, particularly deep learning algorithms, into the analysis of panoramic radiographs has shown promising potential for enhancing surgical planning.

Recent studies have explored the use of ML to automate the risk assessment process, helping clinicians identify high-risk cases with greater accuracy. One study developed an artificial intelligence (AI) system to assist in evaluating panoramic radiographs and predicting complications related to third molar extraction. Using 4516 panoramic images, the ML model was trained to detect key anatomical regions, including the dental element and the IAN, with high predictability. The model employs a U-Net deep learning network capable of segmenting these regions and automatically identifying potential risks.[26] This approach could transform clinical practice by enabling more precise risk assessments directly from panoramic radiographs, improving surgical planning and decision-making. Furthermore, ML could predict the likelihood of specific complications, such as nerve injury or excessive bleeding, and potentially guide the selection of the most appropriate surgical approach. Future studies may further refine these AI-based tools to automate the process of identifying at-risk patients and tailor surgical planning to reduce complications and improve patient outcomes.

Some researchers argue that angulation of the third molar is not a risk factor for IAN injury, a view not supported by the findings of this study.[27] The classification of tooth position has been advocated as a strategy to prevent surgical complications arising from the extraction of impacted third molars, providing details on the tooth's position in relation to the bone and the adjacent second molar, as well as its proximity to the mandibular canal, which is essential for detailed surgical planning. This reduces complications and postoperative pain.[27-29]

Mesioangulated third molars are highly prevalent, a finding corroborated by this study.[30,31] The results revealed statistical significance for the Winter classification, with the mesioangulated position increasing the postoperative pain by 95%. This increased pain can be attributed to several mechanical factors. The mesioangulated position often requires more extensive surgical procedures, such as bone removal and tooth sectioning, which results in greater surgical trauma and inflammation. The angulation of the tooth often results in an impaction closely related to the adjacent second molar, making access for odontosection and osteotomy difficult. These difficulties may lead to more extensive manipulation of the surrounding tissues, increasing the risk of soft tissue injury and contributing to postoperative pain. Furthermore, the mesioangulated position is commonly associated with greater proximity to sensitive structures, particularly the IAN. The closer the tooth is to the IAN, the greater the risk of direct trauma or nerve compression during extraction, which can increase postoperative pain and, in some cases, lead to long-term nerve damage or paresthesia. Together, these factors explain why mesioangulated impactions are more likely to result in increased postoperative discomfort and complications.[3,5,7]

Furthermore, in the mesioangular and horizontal positions, there is an increase in the distance between the cementoenamel junctions of the second and third molars, leading to food impaction in the interdental space, difficulty brushing and flossing, and a greater likelihood of pericoronitis. These preexisting inflammatory and painful conditions can worsen postoperative complications.[15,25,31]

This study also revealed that horizontally positioned lower third molars near the IAN are 2.8 times more likely to cause pain. This contradicts findings that did not show a significant correlation between

Table 2: Frequencies of tooth_position × postoperative_complications

Tooth position	Postoperative complications	Account	% of total	Cumulative %
Distoangular	Hematoma	0	0.0%	0.0%
	Pain	8	2.7%	2.7%
	Pain-hematoma	1	0.3%	3.0%
	Pain-swelling	3	1.0%	4.0%
	Pain-swelling-bruising	1	0.3%	4.3%
	Pain-swelling-paresthesia	1	0.3%	4.7%
	Pain-swelling-trismus	0	0.0%	4.7%
	Swelling	6	2.0%	6.6%
	Swelling-Hematoma	1	0.3%	7.0%
	Swelling-Bleeding	0	0.0%	7.0%
	Swelling-Trismus	0	0.0%	7.0%
	Trismus	0	0.0%	7.0%
	No symptoms	1	0.3%	7.3%
Horizontal	Hematoma	1	0.3%	7.6%
	Pain	6	2.0%	9.6%
	Pain-hematoma	0	0.0%	9.6%
	Pain-swelling	12	4.0%	13.6%
	Pain-swelling-bruising	2	0.7%	14.3%
	Pain-swelling-paresthesia	0	0.0%	14.3%
	Pain-swelling-trismus	2	0.7%	15.0%
	Swelling	15	5.0%	19.9%
	Swelling-hematoma	3	1.0%	20.9%
	Swelling-Bleeding	0	0.0%	20.9%
	Swelling-trismus	0	0.0%	20.9%
	Trismus	0	0.0%	20.9%
	No symptoms	1	0.3%	21.3%
Mesioangular	Hematoma	0	0.0%	21.3%
	Pain	13	4.3%	25.6%
	Pain-hematoma	2	0.7%	26.2%
	Pain-swelling	19	6.3%	32.6%
	Pain-swelling-bruising	3	1.0%	33.6%
	Pain-swelling-paresthesia	0	0.0%	33.6%
	Pain-swelling-Trismus	2	0.7%	34.2%
	Swelling	27	9.0%	43.2%
	Swelling-hematoma	3	1.0%	44.2%
	Swelling-bleeding	0	0.0%	44.2%
	Swelling-trismus	1	0.3%	44.5%
	Trismus	1	0.3%	44.9%
	No symptoms	15	5.0%	49.8%
Vertical	Hematoma	2	0.7%	50.5%
	Pain	25	8.3%	58.8%
	Pain-hematoma	2	0.7%	59.5%
	Pain-swelling	13	4.3%	63.8%
	Pain-swelling-bruising	1	0.3%	64.1%
	Pain-swelling-paresthesia	0	0.0%	64.1%
	Pain-swelling-trismus	1	0.3%	64.5%
	Swelling	53	17.6%	82.1%
	Swelling-hematoma	7	2.3%	84.4%
	Swelling-bleeding	1	0.3%	84.7%
	Swelling-trismus	0	0.0%	84.7%
	Trismus	0	0.0%	84.7%
	No symptoms	46	15.3%	100.0%

Table 3: Omnibus likelihood ratio tests

Predictor	X^2	Df	*P* value
Age	13.4	12	0.343
Side	12.3	12	0.424
Proximity tooth mandibular canal	74.6	72	0.392
Tooth position	60.2	36	0.007

postoperative positioning and sensitivity.[32,33] However, these discrepancies may be due to differences in the subjective methods used to measure pain.

The widely used panoramic radiograph classification highlights signs suggesting proximity between the root apices and the mandibular canal, including root darkening, root deflection, root narrowing, a bifid root apex, mandibular canal deviation, canal narrowing, and canal disruption.[34] This proximity was significant in the present study, which aligns with the assertion that the risk of paresthesia due to IAN injury during the removal of the lower third molar is highly dependent on the anatomical relationship between the nerve and the tooth.

Most cases of paresthesia involve mesioangular teeth.[25,30,32] The etiology of postoperative pain and edema is complex and multifactorial, with no consensus on a single causal factor for these complications.[5,12,28] The contributing factors include the patient's age and sex, smoking, poor oral hygiene, lack of postoperative care, the surgeon's experience, surgical trauma, anatomical location, failure of aseptic technique, local anesthesia, alveolar curettage, deficient local blood supply, fibrinolysis, removal of clots, presence of infectious processes, and use of oral contraceptives. Edema is considered a normal postoperative response, usually peaking 2 to 3 days after surgery and then decreasing.[15,18,24,31]

In the present study, older patients presented a greater risk of postoperative complications, such as edema, which is consistent with previous findings. As bone elasticity and regenerative capacity are better at younger ages, complications are more likely to arise with advancing age.[2,31,32] Thus, evaluating the proximity of third molars to the IAN and assessing potential postoperative complications can minimize temporary and permanent damage, emphasizing the importance of radiographic or tomographic evaluation of this relationship. However, randomized clinical trials have not shown a significant reduction in IAN disturbances when CT is used compared with panoramic radiography for extractions.[22,27,35]

Future studies could investigate minimally invasive surgical approaches combined with planning techniques based on CBCT, which offer more precise visualization of the anatomical structures involved. The comparative analysis of the development of personalized imaging protocols with CBCT and minimally invasive surgical management, considering the results of the present study, could contribute to understanding the factors that reduce complications and improve the patient experience during third molar removal surgery. For patients with mesioangular or horizontal impacts identified via panoramic radiographs, clinicians should consider more conservative strategies to minimize trauma, such as coronectomy, which aims to preserve the roots of the tooth while avoiding the risk of IAN injury. Coronectomy has been shown to be effective in reducing nerve injuries, especially in patients at greater risk of complications, such as those with teeth in close proximity to the nerve. Additionally, preoperative counseling should be provided, explaining the increased risk of complications such as pain, swelling, infection, and alveolitis in these situations. For postoperative pain management, the use of more aggressive and personalized protocols, which may include stronger analgesics and anti-inflammatory drugs as needed to ensure patient comfort, is recommended. These strategies should be tailored on the basis of the surgical technique chosen, considering the position and proximity of the tooth to vital structures.[36]

Conclusion

The position of impacted mandibular third molars, particularly mesioangular and horizontal angulations, significantly influences the incidence of postoperative pain and swelling. These findings emphasize the importance of considering tooth position in surgical planning to minimize postoperative complications. Although panoramic radiography remains a valuable tool, especially in settings with limited resources, CBCT is recommended for complex cases or when close proximity to vital structures is suspected.

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Conflicts of interest

There are no conflicts of interest.

Author contributions

The author DNM was the creator and executor of the study, supervised by the author FKP, and cosupervised by the author RSO. All the authors reviewed the final

Table 4: Model coefficients – postoperative_complications

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
Hematoma - no symptoms	Intercept	−70.669	−71.2635	−70.074	0.303	−232.9020	<.001	2.04E-31	1.12E-31	3.69E-31
	AGE:									
	≥17 – <17	−62.951	−63.5456	−62.356	0.303	−207.4664	<.001	4.58E-28	2.53E-28	8.30–18
	SIDE:									
	Right – Left	44.611	44.0161	45.206	0.303	147.0233	<.001	2.37e+19	1.31e+19	4.29e+19
	Proximity_tooth_ mandibular canal:									
	Canal_deviation – Root_deflection	−7.924	In	In	In	In	In	3.62e0-4	In	In
	Canal_narrowing – Root_deflection	−19.026	In	In	In	In	In	5.46E0-9	In	In
	Interruption_channel – Root_deflection	−8.348	In	In	In	In	In	2.37e0-4	In	In
	Root_apex_bifid_root – Root_deflection	−18.572	−18.5720	−18.572	3.32E-14	−5.59e−14	<.001	8.60e0-9	8.60e0-9	8.60e0-9
	Root_darkening – Root_deflection	87.296	85.6458	88.946	0.842	103.7001	<.001	8.17e+37	1.57e+37	4.25e+38
	Root_narrowing – Root_deflection	86.534	84.9812	88.088	0.792	109.1933	<.001	3.81e+37	8.07e+36	1.80e+38
	Tooth_position:									
	Distoangular-Vertical	−18.871	−18.8709	−18.871	1.66e0-9	−1.14e−10	<.001	6.37e0-9	6.37e0-9	6.37e0-9
	Horizontal – Vertical	3.880	0.2314	7.528	1.861	2.0843	0.037	48.4150	1.2604	1859.7910
	Mesioangular-Vertical	−35.732	In	In	In	In	In	3.03E-16	In	In
Pain - no symptoms	Intercept	119.470	118.0469	120.894	0.726	164.5060	<.001	7.68e+51	1.85e+51	3.19e+52
	AGE:									
	≥17 – <17	−119.690	−120.8526	−118.527	0.593	−201.7079	<.001	1.05E-52	3.27E-53	3.35E-52
	SIDE:									
	Right – Left	−1.009	−2.5214	0.503	0.771	−1.3083	0.191	0.3645	0.0804	1.6532
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	−63.099	−63.0994	−63.099	9.45E-15	−6.68e−15	<.001	3.95E-28	3.95E-28	3.95E-28
	Canal_narrowing – Root_deflection	0.793	−2.0896	3.675	1.471	0.5390	0.590	2.2091	0.1237	39.4386
	Interruption_channel – Root_deflection	−96.704	In	In	In	In	In	1.00E-42	In	In
	Root_apex_bifid_root – Root_deflection	0.146	−1.5702	1.863	0.876	0.1669	0.867	1.1574	0.2080	6.4399

Table 4. Continued

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
	Root_darkening – Root_deflection	0.894	−0.7461	2.534	0.837	1.0683	0.285	2.4447	0.4742	12.6030
	Root_narrowing – Root_deflection	−0.481	−2.1329	1.170	0.843	−0.5711	0.568	0.6180	0.1185	3.2232
	Tooth_position:									
	Distoangular-vertical	2.785	0.3842	5.187	1.225	2.2736	0.023	16.2072	1.4685	178.8783
	Horizontal – vertical	1.996	−0.5521	4.544	1.300	1.5353	0.125	7.3580	0.5757	94.0366
	Mesioangular-vertical	0.123	−1.2576	1.504	0.705	0.1750	0.861	1.1312	0.2843	4.5004
Pain-Hematoma - no symptoms	Intercept	−18.640	−20.8071	−16.473	1.106	−16.8593	<.001	8.03e0-9	9.20E-10	7.01e0-8
	AGE:									
	≥17 – <17	14.754	12.5872	16.921	1.106	13.3446	<.001	2.56e0+6	292791.1088	2.23e0+7
	SIDE:									
	Right – Left	−0.128	−3.1863	2.929	1.560	−0.0823	0.934	0.8795	0.0413	18.7179
	Proximity_tooth_ mandibular canal:									
	Canal_deviation – Root_deflection	−12.751	In	In	In	In	In	2.90e0-6	In	In
	Canal_narrowing – Root_deflection	−35.793	In	In	In	In	In	2.85E-16	In	In
	Interruption_channel – Root_deflection	−68.273	−68.2732	−68.273	1.36E-14	−5.02e−15	<.001	2.24E-30	2.24E-30	2.24E-30
	Root_apex_bifid_root – Root_deflection	1.975	−0.9236	4.873	1.479	1.3354	0.182	7.2044	0.3971	130.7128
	Root_darkening – Root_deflection	−46.768	−46.7678	−46.768	9.26E-15	−5.05e−15	<.001	4.89E-21	4.89E-21	4.89E-21
	Root_narrowing – Root_deflection	0.901	−2.2834	4.085	1.625	0.5546	0.579	2.4621	0.1019	59.4674
	Tooth_position:									
	Distoangular-vertical	4.207	0.2880	8.126	1.999	2.1040	0.035	67.1481	1.3338	3380.4082
	Horizontal – vertical	−12.227	−12.2269	−12.227	1.77e0-6	−6.90e0-6	<.001	4.90e0-6	4.90e0-6	4.90e0-6
	Mesioangular-vertical	1.733	−0.8688	4.334	1.327	1.3054	0.192	5.6558	0.4195	76.2599
Pain-swelling – no symptoms	Intercept	−22.643	−23.4671	−21.819	0.420	−53.8633	<.001	1.47E-10	6.43E-11	3.34E-10
	AGE:									
	≥17 – <17	21.922	21.0977	22.746	0.420	52.1470	<.001	3.31e0+9	1.45e0+9	7.56e0+9
	SIDE:									
	Right – Left	−0.982	−2.4565	0.493	0.752	−1.3052	0.192	0.3746	0.0857	1.6365

Table 4. Continued

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
	Proximity_tooth_ mandibular canal:									
	Canal_deviation – Root_deflection	36.371	34.8104	37.933	0.796	45.6657	<.001	6.25e+15	1.31e+15	2.98e+16
	Canal_narrowing – Root_deflection	−0.739	−3.9898	2.511	1.659	−0.4457	0.656	0.4775	0.0185	12.3234
	Interruption_channel – Root_deflection	−0.497	−3.0578	2.063	1.306	−0.3807	0.703	0.6081	0.0470	7.8700
	Root_apex_bifid_root – Root_deflection	−0.138	−1.9762	1.701	0.938	−0.1468	0.883	0.8713	0.1386	5.4783
	Root_darkening – Root_deflection	1.412	−0.1895	3.013	0.817	1.7280	0.084	4.1030	0.8274	20.3466
	Root_narrowing – Root_deflection	0.338	−1.1426	1.818	0.755	0.4473	0.655	1.4020	0.3190	6.1617
	Tooth_position:									
	Distoangular-vertical	−67.640	In	In	In	In	In	4.21E-30	In	In
	Horizontal – vertical	3.523	1.1369	5.908	1.217	2.8940	0.004	33.8761	3.1172	368.1452
	Mesioangular-vertical	1.115	−0.1540	2.383	0.647	1.7220	0.085	3.0485	0.8572	10.8408
Pain-Swelling-Hematoma - no symptoms	Intercept	−32.238	−32.9173	−31.559	0.347	−93.0196	<.001	9.98e-15	5.06E-15	1.97E-14
	AGE:									
	≥17 – <17	−9.938	−10.6170	−9.258	0.347	−28.6743	<.001	4.83e0-5	2.45E0-5	9.53e0-5
	SIDE:									
	Right – Left	39.812	39.1325	40.491	0.347	114.8729	<.001	1.95e+17	9.89e+16	3.85e+17
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	115.733	115.7330	115.733	7.44e0-9	1.56e+10	<.001	1.83e+50	1.83e+50	1.83e+50
	Canal_narrowing – Root_deflection	−52.331	−52.3312	−52.331	6.27E-16	−8.35e−16	<.001	1.87E-23	1.87E-23	1.87E-23
	Interruption_channel – Root_deflection	−69.662	−69.6621	−69.662	4.92E-19	-1.42e−20	<.001	5.57E-31	5.57E-31	5.57E-31
	Root_apex_bifid_root – Root_deflection	−63.908	−63.9081	−63.908	3.86E-23	−1,65e−24	<.001	1.76E-28	1.76E-28	1.76E-28
	Root_darkening – Root_deflection	−53.889	−53.8892	−53.889	5.44E-24	−9.90e−24	<.001	3.95e-24	3.95e-24	3.95e-24
	Root_narrowing – Root_deflection	−55.459	−55.4589	−55.459	9.83E-25	−5.64e−25	<.001	8.21E-25	8.21E-25	8.21E-25
	Tooth_position:									
	Distoangular-vertical	−16.195	−16.1951	−16.195	2.40e0-8	−6.75e0−8	<.001	9.26e0-8	9.26e0-8	9.26e0-8

Table 4. Continued

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
	Horizontal – vertical	−99.416	−99.4160	−99.416	2.66E-10	−3.73e−11	<.001	6.67E-44	6.67E-44	6.67E-44
	Mesioangular-vertical	1.224	−1.7100	4.157	1.497	0.8175	0.414	3.3996	0.1809	63.8973
Pain-Swelling-Paresthesia - no symptoms	Intercept	−161.032	−161.0318	−161.032	2.47E-12	−6.51e−13	<.001	1.16E-70	1.16E-70	1.16E-70
	AGE:									
	≥17 – <17	−50.341	−50.3415	−50.341	3.73E-13	−1.35e−14	<.001	1.37E-22	1.37E-22	1.37E-22
	SIDE:									
	Right – Left	93.276	93.2758	93.276	2.47E-12	3.77e+13	<.001	3.23e+40	3.23e+40	3.23e+40
	Proximity_tooth_ mandibular canal:									
	Canal_deviation – Root_deflection	−2.798	−2.7983	−2.798	7.26E-32	−3.85e−31	<.001	0.0609	0.0609	0.0609
	Canal_narrowing – Root_deflection	3.031	3.0311	3.031	2.38E-30	1.27e+30	<.001	20.7209	20.7209	20.7209
	Interruption_channel – Root_deflection	−42.272	In	In	In	In	In	4.38E-19	In	In
	Root_apex_bifid_root – Root_deflection	71.813	71.8135	71.813	2.12E-12	3.38e+13	<.001	1.54e+31	1.54e+31	1.54e+31
	Root_darkening – Root_deflection	−18.389	−18.3887	−18.389	2.44E-21	−7.53e−21	<.001	1.03e0-8	1.03e0-8	1.03e0-8
	Root_narrowing – Root_deflection	4.581	4.5810	4.581	3.23e-46	1.42e+46	<.001	97.6154	97.6154	97.6154
	Tooth_position:									
	Distoangular-vertical	88.891	88.8911	88.891	2.47E-12	3.59e+13	<.001	4.03e+38	4.03e+38	4.03e+38
	Horizontal – vertical	8.826	8.8265	8.826	7.83E-17	1.13e+17	<.001	6812.1486	6812.1486	6812.1486
	Mesioangular-vertical	−9.365	−9.3654	−9.365	9.61E-25	−9.75e−24	<.001	8.56e0-5	8.56e0-5	8.56e0-5
Pain-Swelling-Trismus - no symptoms	Intercept	−90.457	−91.0645	−89.850	0.310	−292.0722	<.001	5.19e-40	Edição 2.83E-40	9.52E-40
	AGE:									
	≥17 – <17	−66.534	−67.1414	−65.927	0.310	−214.8287	<.001	1.27E-29	6.93E-30	2.33E-29
	SIDE:									
	Right – Left	67.163	66.5557	67.770	0.310	216.8574	<.001	1.47e+29	8.03e+28	2.70e+29
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	−8.928	−8.9283	−8.928	1.19E-57	−7.48e−57	<.001	1.33e0-4	1.33e0-4	1.33e0-4
	Canal_narrowing – Root_deflection	−18.047	−18.0472	−18.047	3.45E-45	−5.23e−45	<.001	1.45e0-8	1.45e0-8	1.45e0-8

Table 4. Continued

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
	Interruption_channel – Root_deflection	−11.744	−11.7436	−11.744	2.97E-43	−3.95e−43	<.001	7.94e0-6	7.94e0-6	7.94e0-6
	Root_apex_bifid_root – Root_deflection	−17.099	−17.0994	−17.099	3.71E−45	−4,61e−45	<.001	3.75e0-8	3.75e0-8	3.75e0-8
	Root_darkening – Root_deflection	87.606	86.3431	88.869	0.644	135.9556	<.001	1.11e+38	3.15e+37	3.94e+38
	Root_narrowing – Root_deflection	87.600	86.4953	88.706	0.564	155.3604	<.001	1.11e+38	3.67e+37	3.34e+38
	Tooth_position:									
	Distoangular-vertical	−14.222	−14.2221	−14.222	1.10e0-7	−1.30e0-8	<.001	6.66e0-7	6.66e0-7	6.66e0-7
	Horizontal – vertical	4.702	1.3404	8.063	1.715	2.7415	0.006	110.1388	3.8205	3175.1020
	Mesioangular-vertical	2.016	−0.6221	4.654	1.346	1.4978	0.134	7.5085	0.5368	105.0255
Swelling - no symptoms	Intercept	118.264	116.8910	119.637	0.700	168.8446	<.001	2.30e+51	5.82e+50	9.07e+51
	AGE:									
	≥17 – <17	−118.990	−120.1539	−117.826	0.594	−200.3560	<.001	2.11E-52	6.57E-53	6.74E-52
	SIDE:									
	Right – Left	0.386	−1.0427	1.814	0.729	0.5292	0.597	1.4706	0.3525	6.1356
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	36.660	35.0988	38.221	0.796	46.0278	<.001	8.34e+15	1.75e+15	3.97e+16
	Canal_narrowing – Root_deflection	−75.221	−75.2207	−75.221	1.99E-32	−3,78e−33	<.001	2.15E-33	2.15E-33	2.15E-33
	Interruption_channel – Root_deflection	0.806	−0.8322	2.445	0.836	0.9645	0.335	2.2397	0.4351	11.5284
	Root_apex_bifid_root – Root_deflection	0.552	−0.8067	1.910	0.693	0.7961	0.426	1.7365	0.4463	6.7561
	Root_darkening – Root_deflection	0.551	−0.9252	2.028	0.753	0.7319	0.464	1.7356	0.3965	7.5981
	Root_narrowing – Root_deflection	0.482	−0.6454	1.610	0.575	0.8383	0.402	1.6198	0.5244	5.0031
	Tooth_position:									
	Distoangular-vertical	0.898	−1.5134	3.309	1.230	0.7297	0.466	2.4540	0.2202	27.3543
	Horizontal – vertical	1.871	−0.4598	4.202	1.189	1.5733	0.116	6.4956	0.6314	66.8231
	Mesioangular-vertical	0.190	−0.8512	1.232	0.531	0.3583	0.720	1.2098	0.4269	3.4283

Table 4. Continued

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
Swelling-Hematoma - no symptoms	Intercept	−58.063	−58.7811	−57.345	0.366	−158.5222	<.001	6.07E-26	2.96E-26	1.25E-25
	AGE:									
	≥17 – <17	−30.379	−31.0966	−29.661	0.366	−82.9391	<.001	6.41E−14	3.13E-14	1.31E-13
	SIDE:									
	Right – Left	85.494	84.7760	86.212	0.366	233.4127	<.001	1.35e+37	6.57e+36	2.76e+37
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	−18.382	−18.3825	−18.382	8.58E-25	−2.14e−25	<.001	1.04E0-8	1.04E0-8	1.04E0-8
	Canal_narrowing – Root_deflection	−50.749	−50.7487	−50.749	1.56E-22	−3.26e−23	<.001	9.12E-23	9.12E-23	9.12E-23
	Interruption_channel – Root_deflection	1.708	−1.5084	4.925	1.641	1.0408	0.298	5.5183	0.2213	137.6286
	Root_apex_bifid_root – Root_deflection	−45.263	−45.2630	−45.263	3.33E-20	−1.36e−21	<.001	2.20e-20	2.20e-20	2.20e-20
	Root_darkening – Root_deflection	2.773	0.2729	5.274	1.276	2.1739	0.030	16.0115	1.3138	195.1356
	Root_narrowing – Root_deflection	1.808	−0.6421	4.259	1.250	1.4464	0.148	6.1010	0.5262	70.7402
	Tooth_position:									
	Distoangular-vertical	1.210	−1.9599	4.379	1.617	0.7480	0.454	3.3524	0.1409	79.7761
	Horizontal – vertical	2.804	0.0216	5.586	1.419	1.9751	0.048	16.5048	1.0218	266.6019
	Mesioangular-vertical	−0.595	−2.9599	1.769	1.206	−0.4933	0.622	0.5514	0.0518	5.8678
Swelling-hemorrhage - no symptoms	Intercept	−50.003	−50.5628	−49.443	0.286	−175.0098	<.001	1.92E-22	1.10E-22	3.37E-22
	AGE:									
	≥17 – <17	−43.864	−44.4245	−43.305	0.286	−153.5256	<.001	8.91E-20	5.09E-20	1.56E-19
	SIDE:									
	Right – Left	39.437	38.8774	39.997	0.286	138.0309	<.001	1.34e+17	7.66e+16	2.35e+17
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	1.867	1.8675	1.867	1.57E-43	1.19e+43	<.001	6.4719	6.4719	6.4719
	Canal_narrowing – Root_deflection	2.168	2.1684	2.168	1.13E-27	1.92e+27	<.001	8.7440	8.7440	8.7440
	Interruption_channel – Root_deflection	−1.706	−1.7064	−1.706	4.94E-25	−3.45e−24	<.001	0.1815	0.1815	0.1815

Table 4. Continued

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
	Root_apex_bifid_root – Root_deflection	−0.118	−0.1175	−0.118	5.18E-24	−2.27e−22	<.001	0.8891	0.8891	0.8891
	Root_darkening – Root_deflection	53.606	53.0460	54.166	0.286	187.6207	<.001	1.91e+23	1.09e+23	3.34e+23
	Root_narrowing – Root_deflection	−2.560	−2.5597	−2.560	1.16E-24	−2.20e−24	<.001	0.0773	0.0773	0.0773
	Tooth_position:									
	Distoangular-vertical	−28.962	−28.9616	−28.962	1.44E-13	−2.01E−14	<.001	2.64E-13	2.64E-13	2.64E-13
	Horizontal – vertical	−9.991	−9.9907	−9.991	1.28e0-5	-782262.2894	<.001	4.58e0-5	4.58e0-5	4.58e0-5
	Mesioangular-vertical	−46.967	−46.9672	−46.967	2.71E-21	−1,74e−22	<.001	4.00E-21	4.00E-21	4.00E-21
Swelling-trismus - no symptoms	Intercept	−98.791	−99.2487	−98.333	0.234	−422.7267	<.001	1.25E-43	7.89E-44	1.97E-43
	AGE:									
	≥17 – <17	−78.432	−78.8904	−77.974	0.234	−335.6132	<.001	8.65E-35	Rolamento 5.47E-35	1.37E-34
	SIDE:									
	Right – Left	52.991	52.5332	53.449	0.234	226.7504	<.001	1.03e+23	6.53e+22	1.63e+23
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	2.726	2.7255	2.726	3.98E-59	6.85e+58	<.001	15.2645	15.2645	15.2645
	Canal_narrowing – Root_deflection	−7.359	−7.3589	−7.359	8.46E-30	−8.70e−29	<.001	6.37e0-4	6.37e0-4	6.37e0-4
	Interruption_channel – Root_deflection	−12.058	−12.0580	−12.058	5.70E-32	−2.12e−32	<.001	5.80e0-6	5.80e0-6	5.80e0-6
	Root_apex_bifid_root – Root_deflection	−9.611	−9.6111	−9.611	7.20E-31	−1.33e−31	<.001	6.70e0-5	6.70e0-5	6.70e0-5
	Root_darkening – Root_deflection	2.783	2.7833	2.783	1.71E-25	1.63e+25	<.001	16.1730	16.1730	16.1730
	Root_narrowing – Root_deflection	59.819	59.3607	60.277	0.234	255.9650	<.001	9.53e+25	6.03e+25	1.51e+26
	Tooth_position:									
	Distoangular-vertical	10.273	10.2735	10.273	1.23E-47	8.34e+47	<.001	28954.4378	28954.4378	28954.4378
	Horizontal – vertical	23.129	23.1291	23.129	1.04E-18	2.22e+19	<.001	1.11e+10	1.11e+10	1.11e+10
	Mesioangular-vertical	64.150	63.6922	64.608	0.234	274.4999	<.001	7.25e+27	4.58e+27	1.15e+28
Trismus - no symptoms	Intercept	−69.184	−69.7227	−68.645	0.275	−251.7538	<.001	8.99E-31	5.25E-31	1.54E-30
	AGE:									
	≥17 – <17	−36.960	−37.4985	−36.421	0.275	−134.4934	<.001	8.88E−17	5.18E-17	1.52E-16

Table 4. Continued

Postoperative_ complications	Predictor	Estimate	95% confidence interval		IF	With	*P* value	Odds ratio	95% confidence interval	
			Lower	Upper					Lower	upper
	SIDE:									
	Right – Left	50.330	49.7912	50.868	0.275	183.1451	<.001	7.21e+21	4.21e+21	1.24e+22
	Proximity_tooth_ mandibular canal:									
	Canal_Deviation – Root_deflection	1.650	1.6500	1.650	2.01E-31	8.21e+30	<.001	5.2068	5.2068	5.2068
	Canal_narrowing – Root_deflection	−50.877	−50.8772	−50.877	4.45E-23	−1.14e−24	<.001	8.02E-23	8.02E-23	8.02E-23
	Interruption_channel – Root_deflection	−58.339	−58.3386	−58.339	2.19E-26	−2.66e−27	<.001	4.61E-26	4.61E-26	4.61E-26
	Root_apex_bifid_root – Root_deflection	−58.749	−58.7490	−58.749	2.17E-26	-2.71e−27	<.001	3.06E-26	3.06E-26	3.06E-26
	Root_darkening – Root_deflection	−49.455	−49.4552	−49.455	1.78E-22	−2.79e−23	<.001	3.33E-22	3.33E-22	3.33E-22
	Root_narrowing – Root_deflection	−40.140	−40.1400	−40.140	2.01E-18	−1,99e−19	<.001	3.69E-18	3.69E-18	3.69E-18
	Tooth_position:									
	Distoangular-vertical	6.474	6.4735	6.474	6.51E-22	9.95e+21	<.001	647.7528	647.7528	647.7528
	Horizontal – vertical	19.551	19.5512	19.551	4.73E-16	4.13e+16	<.001	3.10e0+8	3.10e0+8	3.10e0+8
	Mesioangular-vertical	54.674	54.1354	55.213	0.275	198.9531	<.001	5.55e+23	3.24e+23	9.52e+23

version of the manuscript and are fully aware and prepared to provide any clarifications about the study.

Ethical approval and consent to participate

All eligible patients were fully informed about the blinded nature, potential risks and benefits of their participation in the study, and signed an informed consent form prepared in accordance with the updated guidelines of the Guideline for Good Clinical Practice E6 (R2). The study strictly followed the ethical principles established in the Declaration of Helsinki, guaranteeing the privacy and rights of participants at all stages of the study. This study was approved by the ethics committee under number 4,354,361.

Patient declaration of consent

Not applicable.

Data availability statement

Research data supporting this publication are available from the corresponding author upon request.

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