RESEARCH PAPER

Association Between the Position of Impacted Mandibular Third Molars and the Prevalence of External Root Resorption in Adjacent Second Molars: A Cross-Sectional Study

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ABSTRACT

Background: External root resorption (ERR) of adjacent second molars is known to occur because of impacted mandibular third molars (M3M), but its risk differs depending on the location of the impacted M3M in a radiograph.

Objective: To investigate the relationship between the position of impacted mandibular third molars and the prevalence of ERR of adjacent second molars.

Methods: CBCT was used in a cross-sectional study of 216 impacted third molar–second molar pairs. The angulation of third molars was evaluated by Winter's classification, and the depth and ramus relationship were evaluated by Pell and Gregory classification. ERR, its severity, its location, contact with the teeth, and demographic data were recorded. Chi-square/Fisher's exact tests and independent samples t-test were used to evaluate the associations. Independent predictors of ERR were determined by binary logistic regression.

Results: ERR was detected in 103 (47.7%) adjacent second molars. The most common were mesioangular impaction (67.0%), Pell and Gregory class II (61.4%), position C (59.5 %), and direct contact of the two teeth (58.0%). ERR was significantly associated with mesioangular angulation, deeper impaction, direct contact, and increasing age. Multivariable analysis showed that mesioangular impaction (adjusted OR 4.31; 95% CI 2.03–9.15) and direct contact (adjusted OR 3.84; 95% CI 1.80–8.19) retained their significance.

Conclusion: Mesioangular, deeply positioned, and directly contacting mandibular third molars were associated with increased risk of ERR in adjacent second molars.

Keywords: impacted third molar; external root resorption; mandibular second molar..

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1.INTRODUCTION

The impacted third molar of the mandible is one of the most common developmental and eruptive disorders of the teeth in general practice.[1] The impaction is due to lack of eruption space, poor angulation, and their proximity to the ascending ramus and second molar of the mandible.[2] The two most common classifications for impacted third molars are based on their angulation, i-e Winter's classification, and their depth and relationship with the mandibular ramus, i-e Pell and Gregory classification.[3] A total of 1,055 impacted third molars were identified in a cross-sectional radiographic study; the most prevalent impact angle was mesioangular (41.8%), and the most frequent combined impact angle and position of the third molar was the Pell and Gregory position IIB (26.4%).[4]

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While impacted third molars may be symptom-free, they can cause clinically significant pathological changes, such as distal caries, periodontal defects, pulpal complications, and external root resorption (ERR), due to their proximity to the neighboring second molar.[5] ERR is defined as pathological loss of cementum and dentin from the external root surface and can negatively affect the long-term prognosis of the involved second molar.[6] It is important, however, that on conventional two-dimensional radiographs, early resorptive defects can be difficult to detect due to the superimposition of anatomical structures, while cone-beam computed tomography (CBCT) is capable of detecting the relationship between the impacted third molar and the second molar root in three dimensions.[7]

The prevalence of ERR reported with impacted third molars depends on the population, the imaging modality, and the diagnostic criteria. In a cross-sectional study using CBCT, ERR was reported in 47.7% of the neighboring second molars; the risk was especially high when the third molar was mesioangular or was in the Pell and Gregory class IC position.[8] A second study, which used 381 eligible third molar–second molar pairs, found mesioangular, horizontal angulation, Pell and Gregory class B and C, and direct contact between the teeth to be important potential risk factors for ERR.[9] On the other hand, a recent panoramic-radiography study reported a lower prevalence of 4.3%, indicating that a significant amount of resorptive lesions are missed by different imaging techniques.[10]

The location and orientation of the affected third molar are now shown to be more than just descriptive radiographic features, but significant factors in determining the damage to the adjacent second molar. According to a meta-analysis of CBCT studies, the risk of ERR was significantly higher for second molars neighboring mesioangular impacted third molars compared to second molars neighboring vertically positioned third molars.[11] In a similar study using CBCT, there was a correlation between ERR and increased mesial inclination and deeper impaction. A more recent systematic review and meta-analysis published in 2026, which included 26 studies, reported the prevalence of ERR associated with impacted third molars at 31% (95% CI: 26–36%) and that ERR prevalence was higher for impacted third molars that exhibited mesioangular, horizontal, and transverse impactions, specifically when they made contact with the apical third of the root of the second molar.[7]

However, the prevalence of ERR and the association of the ERR with certain positions of the third molars continue to vary considerably, despite the increasing evidence. This is especially important in clinical decision-making when the clinically normal impacted third molar is silently causing damage to the adjacent second molar, turning a preventable radiographic diagnosis into irreversible tooth damage. The identification of the most strongly associated ERR positions in impacted mandibular third molars can therefore assist the clinician in identifying which teeth are at risk, facilitate radiographical assessment, and aid in the timing of appropriate preventive or surgical intervention. Thus, the present study aimed to analyze the correlation of the position of impacted mandibular third molars and the prevalence of external root resorption in adjacent mandibular second molars. The goal of this study was to evaluate the prevalence of ERR and evaluate its association with third molar angulation and position as determined by the accepted radiographic classification.

2.METHODS

A cross-sectional analytical study was conducted over a period of 122 months from April 2025 to March 2026.

The sample size was determined with OpenEpi version 3.01 based on the single-proportion formula. The expected frequency of external root resorption was set at 47.7%, as found by Lacerda-Santos et al. that 47.7% of the patients had a mandibular second molar with ERR adjacent to an impacted mandibular third molar evaluated by CBCT.[4] A 95% confidence level and 7% absolute precision were used. The minimum sample size calculated was 216 affected 3rd molar–2nd molar pairs of the mandible.

A non-probability consecutive sampling technique was used. CBCT scans of patients 18 years and older were included if they showed at least one impacted mandibular third molar and a fully developed adjacent second molar in the mandible. The affected third molar should be sufficiently visualized on the CBCT scan to enable angulation assessment following winter's classification and depth/relationship with the mandibular ramus following the Pell and Gregory classification. There should be no significant image distortion or artefacts in the adjacent second molar, and its roots should be clearly visible. Only scans that clearly showed the relationship of the affected third molar to the adjacent second molar were included. Scans with cysts, tumors, extensive periapical or periodontal disease affecting the study teeth, incomplete root development, or covering too many radiographical artefacts to visualize the root surface were also excluded. Patients with missing second molars or third molars who did not have sufficient radiographic visualizations were also excluded.

Eligible CBCT scans were identified and assessed with the available three-dimensional radiographic viewing software. Demographic data were obtained for each patient. The side of impaction was recorded for each impacted molar third and second molar pair, and the third molar angulation was classified as vertical, mesioangular, distoangular, or horizontal based on winter's classification system.[12] Pell and Gregory classification was used to evaluate the depth of the involved third molar and relationship with the mandibular ramus. The relationship of the third molar with the adjacent second molar was also recorded as either opposition or contact.[3]

Multiplanar CBCT images consisting of axial, sagittal, and coronal views were used to evaluate the external root resorption of the adjacent second molar. When a root loss in the area of the second molar opposite to the third molar was noted on the outside of the tooth, the loss was classified as ERR. The site of resorption was divided into cervical, middle, and apical thirds, and the amount of root structure that was resorbed was classified. Previous CBCT studies have also evaluated the presence, location, and severity of ERR and its association with the angle and depth of the third molar.

Radiographic evaluation was made by a trained oral and maxillofacial radiologist to increase reliability. Intra-observer agreement was determined by re-evaluation of a subset of randomly selected CBCT scans after an appropriate period. A second experienced observer independently reviewed the selected scans, where necessary, and disagreements were resolved by consensus.
The data obtained were entered and analyzed via IBM SPSS Statistics 26.0. The continuous variable was summarized as mean ± standard deviation, and the categorical variables (gender, third molar angulation, Pell and Gregory position, and the presence or absence of ERR) were summarized as frequency and percentage. The prevalence of ERR was determined as the percentage of adjacent mandibular second molars with radiographically apparent external root resorption.
The relationship between the position of the third molars and ERR was first analyzed using the Pearson chi-square test and Fisher's exact test. The associations with categorical variables such as Pell and Gregory classification and winter's angulation were assessed. This was followed by binary logistic regression to identify independent factors associated with ERR. ERR was used as an outcome variable, while third molar position, angulation, age, gender, and other clinically relevant variables were used as predictor variables. An adjusted odds ratio (OR) with a 95% confidence interval (CI) was reported. A p-value of less than 0.05 was defined as statistically significant.

3.RESULTS

A total of 216 impacted mandibular third molar–second molar pairs were evaluated. The average age of the patients was 29.8 ± 7.4 years, and the most prevalent winter classification was mesioangular impaction (42.1%). The adjacent second molars showed external root resorption in 103 (47.7%). Resorption was most common in the middle third of the roots of affected teeth (50.5%), and was mostly mild (59.2%). (Tables 1–2)
Third molar angulation, Pell and Gregory class, impaction depth, and direct contact with the adjacent second molar were significant factors associated with ERR. The prevalence rate was the highest for mesioangular impaction (67.0%), Pell and Gregory class II (61.4%), position C (59.5%), and direct tooth contact (58.0%). The age was also significantly higher in patients with ERR, while gender and side of impaction were not significantly related with resorption. (Table 3)
In the multivariable logistic regression, the associations of mesioangular impaction, Pell and Gregory class II/III, direct contact, and increasing age with ERR persisted as independent risk factors. The strongest association was for mesioangular impaction, with the adjusted odds of ERR being around 4 times greater than vertical impaction (adjusted OR 4.31, 95% CI 2.03–9.15; $p<0.001$). (Table 4)
Excellent intra- and inter-observer agreement was achieved with radiographic assessment across all classifications and ERR assessment (Table 5).

Table 1. Demographic and radiographic characteristics of the study participants (n=216)

Variable	Category	n (%) / Mean ± SD
Age (years)	Mean ± SD	29.8 ± 7.4
Gender	Male	119 (55.1)
	Female	97 (44.9)
Side of impaction	Right	108 (50.0)
	Left	108 (50.0)
Winter's classification	Vertical	61 (28.2)
	Mesioangular	91 (42.1)
	Horizontal	47 (21.8)
	Distoangular	17 (7.9)
Pell and Gregory class	Class I	96 (44.4)
	Class II	88 (40.7)
	Class III	32 (14.8)
Pell and Gregory depth	Position A	83 (38.4)
	Position B	91 (42.1)
	Position C	42 (19.4)
Direct contact with second molar	Yes	157 (72.7)
	No	59 (27.3)

Table 2. Prevalence and characteristics of external root resorption in adjacent mandibular second molars (n=216)

Variable	Category	n (%)
External root resorption	Present	103 (47.7)
	Absent	113 (52.3)
Among teeth with ERR (n=103)		
Location of resorption	Cervical third	24 (23.3)
	Middle third	52 (50.5)
	Apical third	27 (26.2)
Severity	Mild	61 (59.2)
	Moderate	31 (30.1)
	Severe	11 (10.7)

Table 3. Association of demographic and radiographic characteristics with external root resorption (n=216)

Variable	Category	ERR present n (%)	ERR absent n (%)	p-value
Age (years), mean ± SD		31.1 ± 7.6	28.6 ± 7.1	0.013[a]
Gender	Male	58 (48.7)	61 (51.3)	0.754[b]
	Female	45 (46.4)	52 (53.6)	
Side	Right	55 (50.9)	53 (49.1)	0.391[b]
	Left	48 (44.4)	60 (55.6)	
Direct contact	Yes	91 (58.0)	66 (42.0)	<0.001[b]
	No	12 (20.3)	47 (79.7)	
Winter's classification	Vertical	17 (27.9)	44 (72.1)	
	Mesioangular	61 (67.0)	30 (33.0)	
	Horizontal	22 (46.8)	25 (53.2)	<0.001[b]
	Distoangular	3 (17.6)	14 (82.4)	
Pell and Gregory class	Class I	30 (31.3)	66 (68.8)	
	Class II	54 (61.4)	34 (38.6)	<0.001[b]
	Class III	19 (59.4)	13 (40.6)	
Pell and Gregory depth	Position A	27 (32.5)	56 (67.5)	
	Position B	51 (56.0)	40 (44.0)	0.004[b]
	Position C	25 (59.5)	17 (40.5)	

[a] Independent-samples t-test; [b] Pearson chi-square test/Fisher's exact test

Table 4. Binary logistic regression analysis of factors associated with external root resorption

Predictor	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age, per 1-year increase	1.05 (1.01–1.09)	0.013	1.04 (1.00–1.08)	0.041
Female vs male	0.91 (0.54–1.54)	0.754	0.88 (0.50–1.54)	0.653
Mesioangular vs vertical	5.25 (2.58–10.69)	<0.001	4.31 (2.03–9.15)	<0.001
Horizontal vs vertical	2.27 (0.99–5.20)	0.053	2.01 (0.84–4.82)	0.116
Distoangular vs vertical	0.55 (0.14–2.16)	0.394	0.61 (0.15–2.52)	0.493
Pell and Gregory class II vs I	3.50 (1.91–6.42)	<0.001	2.61 (1.37–4.98)	0.004
Pell and Gregory class III vs I	3.20 (1.44–7.10)	0.004	2.39 (1.02–5.58)	0.045
Direct contact vs no contact	5.39 (2.65–10.96)	<0.001	3.84 (1.80–8.19)	<0.001

Table 5. Intra-observer and inter-observer agreement for radiographic assessment

Radiographic assessment	Intra-observer κ	Inter-observer κ
Presence of external root resorption	0.91	0.87
Winter's classification	0.93	0.90
Pell and Gregory classification	0.89	0.86

4.DISCUSSION

The present study demonstrated that external root resorption (ERR) of the adjacent mandibular second molar was relatively common, occurring in 47.7% of the evaluated second molars associated with impacted mandibular third molars. This is indeed supportive of the idea that an impacted third molar could be a significant local risk factor for irreversible damage to the adjacent second molar. The prevalence in the present study was higher than that of 320 second molars in a CBCT-based study conducted by Sakhdari et al. (2021), which showed the mandibular ERR to be 33.4%. In that study, neither age, gender, nor impaction depth were significant predictors, but the mesioangular and horizontal position of the third molars were significantly associated with ERR.[13] This higher prevalence in the present study may be attributed to the fact that only the mandibular teeth were assessed, the strict use of the CBCT assessment, and the variation in the criteria for the definition of resorption, as well as the differences between the populations.

One of the main findings of the present study was the positive correlation between the angulation of the third molar and ERR. The prevalence of ERR was highest in mesioangular impactions (67.0%) and horizontal impactions (46.8%) than in vertical impactions (27.9%). This result was similar to that of Sakhdari et al., who found significantly higher ERR for mesioangular and horizontal third molars.[13] Likewise, a cross-sectional CBCT study in 2023 with 381 eligible impacted third molar-second molar pairs revealed that mesioangular and horizontal inclinations were significant risk factors for ERR.[9] The biological explanation seems logical due to the mesioangular and horizontal placement of third molars, which may lead to prolonged direct contact of the distal or distobuccal root surface of the second molar. Occlusal load and chronic inflammation at the contact site, as well as mechanical stimulation at the contact site, may stimulate resorptive activity.

The present findings were also consistent with the findings of Cui et al. (2024), who conducted a CBCT study on 578 impacted mandibular third molars and found a significant correlation between the position of impacted mandibular third molars and the ERR of adjacent second molars. They highlighted that these factors as the angulation of the third molar, depth of impaction, and relationship to the second molar were crucial. The uniformity of the various populations supports the idea that the orientation of the third molar is not a mere radiographical descriptive characteristic, but is clinically significant.[14]

Another significant relationship that was found in the present study was between the Pell and Gregory classification and ERR. The percentages of ERR were 61.4% for second molars adjacent to class II and 59.4% for third molars adjacent to class III, while the percentage for class I was 31.3%. However, as the depth increased, so did ERR, so that in position C, ERR was found to be 59.5%, compared to 32.5% in position A. The 2023 CBCT study further confirmed that Pell and Gregory classes B and C are important potential risk factors for ERR.[9] The 2024 retrospective study conducted by Hamad also revealed that the impaction depth had a significant relationship with ERR, with 90.6% of the cases of ERR being related to position C third molars.[10] These findings combined indicate that there may be a higher risk of the third molar remaining in proximity to the second molar root, after impaction, due to greater impaction.

The importance of direct contact between the impacted third and second molars was particularly evident in the present study. The presence of direct contact was also associated with ERR in 58.0% of the second molars with direct contact, versus 20.3% without direct contact, and direct contact was independently associated with ERR after multivariable adjustment (adjusted OR 3.84; 95% CI 1.80–8.19). This is all the more important as the 2023 CBCT study showed the contact area between the third and second molars to be a key risk factor.[9] It also has clinical significance since if the occlusal plane of the impacted tooth is mesioangular or horizontal in orientation and there is direct root contact, this could alert the clinician to the need for careful radiographic evaluation.

However, the prevalence in the current study was greater than that of Hamad et al. 2024 which found ERR in 4.3% of 750 panoramic radiographs. In the resorption cases, however, 65.6% were related to mesioangular third molars, and 90.6% were related to position C; mesioangular third and position C were most common. This large difference in overall prevalence needs to be looked at in the context of the imaging modality. Panoramic radiography is more prone to anatomical superimposition and may not show an early or small resorptive defect, which may be seen on CBCT.[10] A 2022 systematic review that focused solely on the comparison between CBCT and panoramic radiography found that CBCT can change the detection of ERR and enhance the assessment of pathological changes in the second molars next to impacted third molars.[15]

It was observed from the present study that ERR occurred most frequently in the middle third (50.5%) followed by the apical and cervical thirds. The percentage of ERR lesions in the middle third was similar to the 2024 panoramic study by Hamad et al., which found that 59.3% of ERR lesions were located in the middle third. The distribution of resorption sites has not been consistently reported among studies, though.[10] Previous CBCT studies have shown that its location can vary depending upon the angulation and

the relationship of the third molar.[16, 17] Differences can occur because of the three-dimensional relationship of the third molar with the root of the second molar, or because of various classification systems used to document ERR.[15]

The results of the present study are also consistent with the results of the prediction-model study conducted by Kou et al. in 2,156 impacted third molars of 798 patients with the specific goal of determining predictors of ERR for the second molars. In that study, the development of a prediction model further supports the notion that ERR is not solely due to third molar impaction.[18] This is similar to our multivariable results where mesioangular angulation, deeper Pell and Gregory position, direct contact, and age were all independently associated with ERR after controlling for other factors.

In a similar study, Eren et al. (2025) studied 400 mandibular third molars using CBCT and focused on the correlation between the position of the third molars and the occurrence and severity of ERR. They also noted the significance of the position and depth of impaction in relation to any risk of adjacent second molar damage. These findings corroborate the present study's results in which the risk of ERR was not uniformly distributed among all the affected third molars, but was localized in specific radiographic patterns.[19]

A 2025 CBCT study by Abat et al. also found pathological changes in second molars in close relationship to impacted third molars, including ERR, and compared CBCT with panoramic X-rays. Their results confirmed the benefit of 3D imaging for the detection of pathological changes and the assessment of anatomy associated with risk factors. This is especially significant for the present study as the relatively high prevalence of ERR found with CBCT raises the question of whether conventional radiography would underestimate the clinically relevant root damage.[20,22]

The findings of the present study have been supported by other more recent evidence. In a 2025 CBCT study, Wang et al. examined 69 second molars with ERR associated with impacted third molars, and concluded that there was a significant number of second molars in the mandible. Importantly, the presence of complete bony impaction was significantly related to resorption involvement of the pulp chamber, suggesting that deeper impaction may not only be associated with more frequent involvement of ERR, but may also have a significant effect on the severity of the ERR. This finding is consistent with our previous one that deeper positions of Pell and Gregory were linked to a higher prevalence of ERR.[21,23]

The present results and literature review suggest that the group of third molar impactations should not be considered a homogeneous group. Mesioangular or horizontal angulation and deeper impaction, as well as direct contact with the adjacent second-molar root, all typify a subgroup that is significantly at higher risk of ERR. The clinical relevance of this association is significant, as the association of ERR is generally irreversible and can be silent until clinical signs appear. CBCT evaluation may then be especially important if there is a radiologic impression that there is intimate contact between the impacted third molar and the adjacent second molar.

Clinicians should not make a decision on the basis of any symptom alone, but must take into account the three-dimensional relationship of the third molars in relation to each other and the other teeth when determining whether to choose a surveillance or preventive intervention. The present study therefore contributes to the increasing body of evidence that radiographic position can be used as a useful indicator for the presence of second molars at higher risk of irreversible root damage.

5.LIMITATIONS

There were a number of limitations in this study. A cross-sectional design permitted the evaluation of the association between position of impacted mandibular third molars and external root resorption (ERR), but it could not establish causal or temporal relationships. The use of non-probability consecutive sampling from a single institution may have limited the generalizability of the findings to other populations. Although CBCT provided detailed three-dimensional assessment, the study was dependent on the quality and field of view of existing scans. Some confounding factors (e.g., length of impaction, periodontal status, occlusal forces, previous symptoms) could not be fully addressed. Further, subtle resorptive defects could only be classified by radiographic interpretation, even though good intra- and inter-observer agreement was found. Large-scale prospective multicenter studies with standardized CBCT protocols are suggested for the future.

6.CONCLUSION

External root resorption (ERR) of adjacent second molars was common with impacted third molars of the mandible, which were more often mesioangularly positioned, deeply impacted, and in direct contact with the second-molar root. Mesioangular angulation and direct contact had the best individual correlations with ERR. The results highlight the need for thorough three-dimensional radiographic evaluation of impacted third molars, even in asymptomatic patients. High-risk positional patterns may aid in early clinical decision-making and prevent potentially irreversible damage to adjacent second molars.

REFERENCE

1. Al-Madani, S.O., et al., The patterns of impacted third molars and their associated pathologies: a retrospective observational study of 704 patients. Journal of clinical medicine, 2024. 13(2): p. 330.
2. Kuang, Q., et al., Radiographic features of mandibular second molars with eruption
3. disturbances: a retrospective study. Journal of
4. Clinical Medicine, 2023. 12(8): p. 2798.
5. Jacques, E., et al., Radiographic evaluation of impacted third mandibular molar according to the classification of winter, Pell and Gregory in a sample of Cameroonian population. Ethiopian journal of health sciences, 2023. 33(5): p. 851-858.
6. Santos, K.K., et al., Prevalence of Mandibular Third Molars According to the Pell & Gregory and Winter Classifications. J Maxillofac Oral Surg, 2022. 21(2):

p. 627-633.
7. Shah, P.K. and B.S. Chong, Endodontic diagnosis. Endodontic Advances and Evidence-Based Clinical Guidelines, 2022: p. 685-718.
8. Qu, T., et al., Prognosis of second molars with external root resorption caused by adjacent embedded third molars. Journal of endodontics, 2022. 48(9): p. 1113-1120.
9. Liu, W., et al., Association between impacted third molars and external root resorption on adjacent second molars based on cone-beam computed tomography: a systematic review and meta-analysis. BMC Oral Health, 2026. 26(1): p. 1619.
10. Lacerda-Santos, J.T., et al., Prevalence of second molar external root resorption caused by mandibular third molars: a CBCT study. Gen Dent, 2023. 71(1): p. 58-63.
11. Gürses, G., et al., The effect of impacted third molars on second molar external root resorption, a cross-sectional cone beam computed tomography study. Med Oral Patol Oral Cir Bucal, 2023. 28(6): p. e504-e511.
12. Hamad, S.A., External root resorption of second molars due to impacted third molars. J Clin Exp Dent, 2024. 16(12): p. e1489-e1494.
13. Ma, Y., D. Mu, and X. Li, Risk factors for root resorption of second molars with impacted third molars: a meta-analysis of CBCT studies. Acta Odontol Scand, 2023. 81(1): p. 18-28.
14. Simons, R.N., et al., Association of indications for mandibular third molar coronectomy and the Pell and Gregory and the Winter classification systems. Oral and maxillofacial surgery, 2024. 28(2): p. 885-892.
15. Sakhdari, S., et al., Frequency and Severity of Second Molar External Root Resorption Due to the Adjacent Third Molar and Related Factors: A Cone-Beam Computed Tomography Study. Front Dent, 2021. 18: p. 36.
16. Cui, L.-Y., et al., Relationship between the impacted mandibular third molar and adjacent second molar'external root resorption by cone-bean computed tomography analysis. Medicina oral, patologia oral y cirugia bucal, 2023. 29(1): p. e27.
17. Moreira-Souza, L., et al., Comparison of CBCT and panoramic radiography for the assessment of bone loss and root resorption on the second molar associated with third molar impaction: a systematic review. Dentomaxillofacial Radiology, 2022. 51(3).
18. Vasegh, Z., et al., Evaluation of anatomical relationships in the mandibular third molar region based on its angulation and depth of impaction: a CBCT-based study. Oral and Maxillofacial Surgery, 2024. 28(2): p. 613-622.
19. Siddiqui, H.K., et al., Relationship of maxillary third molar root to the maxillary sinus wall: A cone-beam computed tomography (CBCT) based study. Journal of Dental Research, Dental Clinics, Dental Prospects, 2023. 17(1): p. 8.
20. Kou, Z., et al., A prediction model for external root resorption of the second molars associated with third molars. International Dental Journal, 2025. 75(1): p. 195-205.
21. Eren, İ., G. Coşan Ata, and H. Eren, Retrospective Analysis of the Prevalence of External Root Resorption in the Adjacent Mandibular Second Molar Due to Impacted Mandibular Third Molar Using Cone-Beam Computed Tomography. Essentials of Dentistry, 2025. 4: p. 1-9.
22. Kazi, A. K., Jatoi, A., & Hashmani, H. (2025). An Empirical Evaluation of Technology Acceptance Model in Mobile Devices in Healthcare Industry. Journal of Development and Social Sciences, 6(3), 707–714. https://doi.org/10.47205/jdss.2025(6-III)60
23. Jatoi, A., Bibi, M., Hashmani, H., & Ramish, M. S. (2025). Awareness of Patients' Rights and the Respect and Dignity Experienced at Hospitals in Karachi, Pakistan. International Journal of Trends and Innovations in Business & Social Sciences, 3(3), 232–243. https://doi.org/10.5281/zenodo.17359794
24. Abat, V.H., et al., Assessment of marginal bone loss, distal caries, and external root resorption in second molars adjacent to impacted third molars: a retrospective CBCT and panoramic study. BMC Oral Health, 2025. 26(1): p. 128.
25. Wang, K., et al., External root resorption of second molars caused by impacted third molars: CBCT characteristics. Oral and Maxillofacial Surgery, 2025. 29(1): p. 150