

ANATOMICAL RISK FACTORS ASSESSMENT ON ORTHOPANTOMOGRAM AND CONE BEAM COMPUTED TOMOGRAPHY FOR SURGICAL REMOVAL OF LOWER THIRD MOLAR IMPACTIONS

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Abstract

Objective: To evaluate anatomical risk factors associated with impacted mandibular third molars using orthopantomogram (OPG) and cone beam computed tomography (CBCT), and to determine the correlation between panoramic radiographic signs and CBCT-defined high-risk anatomical relationships.

Materials and Methods: This cross-sectional study was conducted at the Department of Oral and Maxillofacial Surgery, MTI-Khyber College of Dentistry, Peshawar, over 12 months. A total of 180 impacted mandibular third molars from patients aged ≥ 18 years who underwent both OPG and CBCT were included. Panoramic radiographs were assessed for classical radiographic signs indicating proximity to the inferior alveolar canal, while CBCT scans evaluated canal position, cortical integrity, and root-canal relationship. Statistical analysis was performed using SPSS version 25.

Results: The mean age of patients was 27.99 ± 6.33 years, with slight male predominance. Mesioangular impaction was the most common pattern. Darkening of roots was the most frequent panoramic sign. CBCT demonstrated a high-risk anatomical relationship in 45% of cases. Among panoramic findings, narrowing of the inferior alveolar canal showed a significant association with high-risk CBCT findings ($p = 0.033$) and was identified as an independent predictor on logistic regression analysis. However, its diagnostic accuracy remained low.

Conclusion: Panoramic radiographic findings alone are insufficient for reliable prediction of high-risk anatomical relationships between impacted mandibular third molars and the inferior alveolar canal. CBCT provides superior anatomical assessment and should be selectively used in cases with suspicious panoramic findings to improve surgical planning and reduce the risk of inferior alveolar nerve injury.

INTRODUCTION:

Impaction of mandibular third molars is one of the most common developmental anomalies encountered in oral and maxillofacial surgery, with a reported prevalence ranging from 16% to 68% worldwide, mandibular impactions being more frequent than maxillary impactions¹⁻³. Genetic factors, dietary habits, and discrepancies between jaw size and tooth size influence the occurrence of impaction in different populations^{4,5}. Surgical removal of impacted mandibular third molars is among the most commonly performed procedures in oral and maxillofacial surgery^{6,7}. Common indications for extraction include recurrent pericoronitis, dental caries, periodontal disease, cystic or neoplastic changes, orthodontic considerations, and prophylactic removal in selected patients^{8,9}.

Although a commonly done surgery, removal of mandibular third molars could give rise to various types of complications, including hemorrhage, alveolar osteitis, post operative infections, mandibular fractures, and inferior alveolar nerve injuries (IANIs)^{10,11}. Among these potential complications, IANIs have been found to be among the most common ones, with a prevalence of transient disturbances up to 8% and permanent neurosensory deficiencies reaching almost 1%^{12,13}. The risk factors for nerve injury during surgical extraction include primarily the degree of anatomical proximity between the roots of the tooth and the IAC, but the list of influencing variables also encompasses other factors like root configuration, angulation of the tooth, depth of impaction, as well as condition of the surrounding cortex^{14,15}. Hence, careful preoperative radiographic evaluation is crucial when planning a surgical procedure.

The standard diagnostic tool used in most dental clinics currently is the orthopantomogram (OPG), which is characterized by wide availability, low radiation exposure compared with other modalities, and affordability^{16,17}. Various signs characteristic for close proximity of the roots of a mandibular third molar and the inferior alveolar canal have long been known, including darkening of roots, diversion or narrowing of the IAC, superior cortical white line break, root narrowing,

and root deflection^{17,18}. Also, the orthopantomogram provides valuable information about tooth angulation and depth of impaction via commonly used classifications, like Winter's classification and Pell and Gregory classification¹⁹.

However, as a two-dimensional diagnostic technique, OPG suffers from certain drawbacks like image magnification, distortion, and overlapping of anatomical structures. It cannot provide adequate representation of bucco-lingual relations, nor can it show any cortical perforations or the spatial orientation of any structures^{20,21}. This issue has been confirmed by the results obtained in several studies where significant discrepancies were reported between panoramic images and intraoperative observations as well as three-dimensional images^{22,23}.

Cone-beam computed tomography (CBCT) has been becoming an important tool recently because it is specially designed for maxillofacial examination^{24,25}. It enables obtaining three-dimensional information related to the relationship between impacted teeth and the inferior alveolar canal, as it is able to visualize precisely the canal position, cortical integrity, IAC narrowing, as well as direct root-to-canal contact^{17,26}. Nonetheless, despite its advantages, the widespread use of CBCT in dental practice is questionable because of its radiation dose, higher cost, and limited access to the diagnostic equipment in some healthcare facilities. Thus, current guidelines recommend using CBCT only selectively in cases with suspicious panoramic findings and/or expected complicated surgery following the ALARA principle²⁷.

Many studies have already been conducted on this topic, doubts remain about the prognostic ability of panoramic signs in detecting high-risk anatomical structures and about the clinical value of CBCT^{14,28}. Moreover, literature on the matter is scarce in developing countries and in South Asia^{30,31}. Thus, the comparison of OPG signs and CBCT-defined anatomical risk factors should help in optimizing preoperative assessment and further development of the selective imaging protocol. This is why the current investigation aimed at estimating the anatomical risk factors of impacted

mandibular third molar surgery using OPG and CBCT and examining the association between panoramic radiographic signs and high-risk anatomical factors on CBCT images.

Materials and Methods

After approval from research review board khyber college of dentistry, this cross-sectional study was carried out in the department of oral and maxillofacial surgery, MTI-khyber college of dentistry, peshawar, pakistan between june 2024 to may 2025. The purpose of the current study was to explore anatomical risk factors in relation to impacted mandibular third molars using orthopantomogram (OPG) and cone beam computed tomography (CBCT). Informed consent was obtained from all subjects prior to data collection, and all patient data remained confidential throughout the study duration.

Subjects aged 18 years and above with impacted mandibular third molars undergoing surgical extraction with prior OPG and CBCT examination were included based on consecutive sampling technique. Subjects with a history of mandibular trauma, past mandibular surgery, presence of pathologies, craniofacial deformities, pregnancy, or poor-quality radiographic images were excluded from the study. Based on OpenEpi software, the sample size requirement was calculated as a minimum of 180 cases. However, all eligible subjects enrolled in the study period were included to improve statistical power.

Radiographic signs indicating close relationship with the IAC, such as darkness of roots, narrowing

of roots, deviation of the canal, narrowing of the canal, loss of continuity of the white line, and root deviation as per the Rood and Shehab criteria, were assessed using panoramic radiographs. Multiplanar reconstructions of CBCT images were also performed to assess the position of the canal in relation to buccolingual, integrity of cortical bone, narrowing of the canal, shape of the roots, and the relationship between roots and the canal. The radiographic assessment was independently made by two examiners, and discrepancies were reconciled by mutual agreement.

Collected data were documented in a proforma and analyzed by using SPSS software version 25. Descriptive statistics were reported as frequencies and percentages, along with mean and standard deviation. Chi-square test and binary logistic regression analysis were performed to investigate possible associations and risk predictors of high-risk anatomy. A significance level of p-value <0.05 was set for this study.

RESULTS

Demographic characteristics

A total of 180 impacted mandibular third molars were included in the study. The mean age of the patients was 27.99 ± 6.33 years (range: 18–47 years). Males constituted 52.2% (n = 94) and females 47.8% (n = 86). Right-sided impactions were observed in 47.2% (n = 85) and left-sided in 52.8% (n = 95). Symptomatic cases accounted for 52.8% (n = 95), while 47.2% (n = 85) were asymptomatic (Table 1).

Table 1. Demographic characteristics of the study population (n = 180)

Variable	Category	Frequency (n)	Percentage (%)
Age	Mean $\pm$ SD	27.99 ± 6.33	—
Gender	Male	94	52.2
	Female	86	47.8
Side	Right	85	47.2
	Left	95	52.8
Symptomatic status	Yes	95	52.8
	No	85	47.2

Impaction characteristics

Mesioangular impaction was the most common angulation (40.6%), followed by horizontal

(19.4%), distoangular (17.8%), and vertical impactions (16.7%). According to Pell and Gregory classification, Position B was most

frequent (37.8%), followed by Position A (34.4%) and Position C (27.8%). In relation to the mandibular ramus, Class II impactions were most

prevalent (41.1%). Straight root morphology was the most frequently observed configuration (41.7%) (Table 2).

Table 2. Impaction characteristics of mandibular third molars

Variable	Category	Frequency (n)	Percentage (%)
Angulation	Mesioangular	73	40.6
	Distoangular	32	17.8
	Horizontal	35	19.4
	Vertical	30	16.7
	Other	10	5.6
Depth	Position A	62	34.4
	Position B	68	37.8
	Position C	50	27.8
Ramus relation	Class I	60	33.3
	Class II	74	41.1
	Class III	46	25.6
Root morphology	Straight	75	41.7
	Curved	45	25.0
	Dilacerated	27	15.0
	Convergent	18	10.0
	Divergent	15	8.3

Panoramic radiographic findings

Darkening of roots was the most common panoramic radiographic sign, followed by

diversion of the canal, interruption of the white line, narrowing of the canal, and root deflection (Table 3).

Table 3. Panoramic radiographic findings

Radiographic sign	Present n (%)	Absent n (%)
Darkening of roots	101 (56.1)	79 (43.9)
Narrowing of roots	72 (40.0)	108 (60.0)
Root deflection	55 (30.6)	125 (69.4)
Diversion of canal	87 (48.3)	93 (51.7)
Narrowing of canal	71 (39.4)	109 (60.6)
White line interruption	80 (44.4)	100 (55.6)

CBCT findings and high-risk anatomical relationship

CBCT evaluation revealed that buccal positioning of the inferior alveolar canal was most common, followed by lingual and inferior positions, while interradicular positioning was least frequent.

Cortical plate integrity was intact in 50.6% of cases, thinned in 37.2%, and perforated in 12.2%. A high-risk anatomical relationship between the mandibular third molar and inferior alveolar canal was observed in 45% (n = 81) of cases (Table 4).

Table 4. CBCT findings

Variable	Category	Frequency (n)	Percentage (%)
Canal position	Buccal	63	35.0
	Lingual	49	27.2
	Inferior	49	27.2
	Interradicular	19	10.6
Cortical status	Intact	91	50.6
	Thinned	67	37.2
	Perforated	22	12.2
High-risk relationship	Yes	81	45.0
	No	99	55.0

Association between panoramic radiographic signs and high-risk relationship

Chi-square analysis demonstrated that most panoramic radiographic signs were not significantly associated with high-risk anatomical relationship on CBCT, including darkening of roots ($p = 0.298$), narrowing of roots ($p = 1.000$),

root deflection ($p = 0.807$), diversion of the canal ($p = 0.730$), and interruption of the white line ($p > 0.05$). However, narrowing of the inferior alveolar canal showed a statistically significant association with high-risk CBCT findings ($\chi^2 = 4.539$, $p = 0.033$) (Table 5).

Table 5. Association between OPG signs and high-risk anatomical relationship

OPG sign	χ^2 value	p-value
Darkening of roots	1.085	0.298
Narrowing of roots	0.000	1.000
Root deflection	0.060	0.807
Diversion of canal	0.119	0.730
Narrowing of canal	4.539	0.033*
White line interruption	—	>0.05

* Statistically significant

Logistic regression analysis

Binary logistic regression analysis demonstrated that narrowing of the inferior alveolar canal was

the only independent predictor of high-risk anatomical relationship (Table 6).

Table 6. Binary logistic regression analysis for prediction of high-risk anatomical relationship

Variable	B	S.E.	Odds Ratio (Exp B)	95% CI Lower	95% CI Upper	p-value
Darkening of roots	-0.478	0.348	0.620	0.314	1.224	0.168
Diversion of canal	0.008	0.354	1.008	0.503	2.022	0.982
Root deflection	-0.120	0.509	0.887	0.327	2.409	0.813
White line interruption	0.467	0.365	1.596	0.780	3.266	0.198
Narrowing of roots	0.092	0.403	1.096	0.498	2.414	0.818
Narrowing of canal	-0.770	0.327	0.463	0.243	0.880	0.019*
Constant	0.385	0.268	1.470	—	—	0.150

* Statistically significant

Diagnostic accuracy of panoramic narrowing of inferior alveolar canal

Narrowing of the inferior alveolar canal demonstrated low diagnostic performance, with sensitivity of 30.9%, specificity of 53.5%, positive

predictive value of 35.2%, negative predictive value of 48.6%, and overall accuracy of 43.3% in detecting high-risk anatomical relationship on CBCT (Table 7).

Table 7. Diagnostic accuracy of OPG narrowing of inferior alveolar canal

Parameter	Value (%)
Sensitivity	30.9
Specificity	53.5
Positive predictive value	35.2
Negative predictive value	48.6
Overall accuracy	43.3

Discussion:

This study evaluated anatomical risk factors associated with impacted mandibular third molars using orthopantomogram (OPG) and cone beam computed tomography (CBCT). The findings demonstrated that most traditional panoramic radiographic signs were not significantly associated with CBCT-defined high-risk anatomical relationships. Although narrowing of the inferior alveolar canal on panoramic imaging showed a statistically significant association and emerged as an independent predictor, its diagnostic accuracy remained low. These findings suggest that panoramic radiography alone has limited reliability for predicting high-risk anatomical relationships and that CBCT provides superior anatomical assessment in selected cases.

The demographic profile and impaction characteristics observed in this study were consistent with previous local and international studies. Most patients were young adults, reflecting the common age group undergoing mandibular third molar surgery because of eruptive abnormalities and associated pathologies^{5,30}. A slight male predominance was observed, which is comparable to findings reported in South Asian populations³¹. Mesioangular impaction was the most frequent pattern, followed by Position B and Class II relationships, which have similarly been reported as the most common impaction patterns in previous studies^{2,3}.

Among panoramic radiographic findings, darkening of roots was the most common sign; however, it did not demonstrate a significant correlation with high-risk anatomical relationships on CBCT. Similar findings have been reported in previous imaging studies, indicating limited sensitivity and specificity of panoramic markers when compared with three-dimensional imaging^{20,22}. The limitations of panoramic radiography may be attributed to its two-dimensional nature, magnification errors, distortion, and inability to accurately determine the buccolingual relationship between the roots and the inferior alveolar canal^{20,21}. Previous CBCT-based studies have also shown that several classical panoramic signs lack sufficient reproducibility in assessing true anatomical proximity²⁶.

CBCT analysis revealed a considerable number of cases with close anatomical relationship between the mandibular third molar and inferior alveolar canal, with buccal canal positioning being the most common finding. Cortical thinning and perforation identified on CBCT are clinically important because they have been associated with increased risk of inferior alveolar nerve exposure and postoperative neurosensory deficits^{13,32}. These findings support the selective use of CBCT in patients with suspicious panoramic radiographic findings.

The present study also demonstrated that narrowing of the inferior alveolar canal on OPG was the only significant predictor of high-risk

anatomical relationship on CBCT. Nevertheless, its low sensitivity, specificity, and overall diagnostic accuracy indicate limited clinical reliability as an isolated screening marker. Similar observations have been reported in systematic reviews evaluating the predictive value of panoramic radiographic signs^{20,22}. Therefore, panoramic radiography should primarily be considered a screening tool, while CBCT should be reserved for cases requiring detailed anatomical assessment and surgical planning.

There were multiple strengths of the current research. Among them were the usage of OPG and CBCT on all the subjects, the development of uniform criteria for radiographic assessment, and the estimation of diagnostic accuracy using regression analysis. However, there were several shortcomings that should be discussed. They include the fact that it was a single-center study, there was no postoperative neurosensory evaluation conducted, and no correlations between surgical findings and radiographs were made during the procedure. Therefore, future multicenter and prospective research is needed to improve predictive capabilities.

Conclusion

Panoramic radiographic findings alone showed limited reliability in predicting the anatomical relationship between impacted mandibular third molars and the inferior alveolar canal. Although narrowing of the canal on orthopantomogram was significantly associated with high-risk anatomical relationships, its diagnostic accuracy was low. Cone beam computed tomography provided superior visualization of canal position and cortical integrity, allowing more accurate identification of high-risk cases. Therefore, OPG should remain the primary screening modality, while CBCT should be selectively used in patients with suspicious panoramic findings to improve surgical planning and reduce the risk of inferior alveolar nerve injury.

Ethical Approval and Consent to Participate

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the

Research Review Board (RRB), Office of the Associate Dean Research, MTI-Khyber College of Dentistry, Peshawar (Approval No. 156/ADR/KCD dated 26/06/2024).

All patients provided informed consent for radiographic imaging as part of routine clinical care. Patient confidentiality and data anonymity were strictly maintained throughout the study.

Consent for Publication

Not applicable. No identifiable patient information or images are included in this manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest related to this study.

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Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

References:

- Pinto AC, Francisco H, Marques D, Martins JNR, Caramês J. Worldwide Prevalence and Demographic Predictors of Impacted Third Molars—Systematic Review with Meta-Analysis. *J Clin Med*. 2024;13(24):7533. DOI: 10.3390/jcm13247533
- Alhajj MN, Amran AG, Alhaidary S, Amran AN, Al-Sosowa AA, Abdulghani EA, et al. Prevalence and pattern of third molars impaction in a large Yemeni sample: a retrospective study. *Sci Rep*. 2024;14(1):22642. DOI: 10.1038/s41598-024-73556-9

- Shaari RB, Awang Naw MA, Khaleel AK, AlRifai AS. Prevalence and pattern of third molars impaction: A retrospective radiographic study. *J Adv Pharm Technol Res.* 2023;14(1):46–50. DOI: 10.4103/japtr.japtr_489_22
- Trakinienė G, Smailienė D, Lopatienė K, Trakinis T, Šidlauskas A. Effect of Genetic and Environmental Factors on the Impaction of Lower Third Molars. *Appl Sci.* 2021;11(4):1824. DOI: 10.3390/app11041824
- Carter K, Worthington S. Predictors of Third Molar Impaction: A Systematic Review and Meta-analysis. *J Dent Res.* 2016;95(3):267–76. DOI: 10.1177/0022034515615857
- Louizakis A, Tatsis D, Grivas T, Tilaveridou S, Tilaveridis I, Kyrgidis A. Prophylactic and Therapeutic Indications for Third Molar Extractions as Compared to Observation and Conservative Management: A Systematic Review and Meta-Analysis. *Surgeries.* 2025;6(2):37. DOI: 10.3390/surgeries6020037
- Sifuentes-Cervantes JS, Carrillo-Morales F, Castro-Núñez J, Cunningham LL, Van Sickels JE. Third molar surgery: Past, present, and the future. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2021;132(5):523–31. DOI: 10.1016/j.oooo.2021.03.004
- Sánchez-Garcés Má, Toledano-Serrabona J, Camps-Font O, Peñarrocha-Diago M, Sánchez-Torres A, Sanmartí-García G, et al. Diagnosis and indications for the extraction of third molars - The SECIB clinical practice guideline. *Med Oral Patol Oral Cirugia Bucal.* 2024;e545–51. DOI: 10.4317/medoral.26524
- Peñarrocha-Diago M, Camps-Font O, Sánchez-Torres A, Figueiredo R, Sánchez-Garcés M, Gay-Escoda C. Indications of the extraction of symptomatic impacted third molars. A systematic review. *J Clin Exp Dent.* 2021;e278–86. DOI: 10.4317/jced.56887
- Bouloux GF, Steed MB, Perciaccante VJ. Complications of Third Molar Surgery. *Oral Maxillofac Surg Clin N Am.* 2007;19(1):117–28. DOI: 10.1016/j.coms.2006.11.013
- Renton T, Smeeton N, McGurk M. Factors predictive of difficulty of mandibular third molar surgery. *Br Dent J.* 2001;190(11):607–10. DOI: 10.1038/sj.bdj.4801052
- He H, Ruan N. Factors influencing inferior alveolar nerve injury after extraction of mandibular third molar. *Med Oral Patol Oral Cirugia Bucal.* 2024;e613–9. DOI: 10.4317/medoral.26576
- Sarikov R, Juodzbals G. Inferior Alveolar Nerve Injury after Mandibular Third Molar Extraction: a Literature Review. *J Oral Maxillofac Res.* 2014;5(4). DOI: 10.5037/jomr.2014.5401
- Guerrero ME, Botetano R, Beltran J, Horner K, Jacobs R. Can preoperative imaging help to predict postoperative outcome after wisdom tooth removal? A randomized controlled trial using panoramic radiography versus cone-beam CT. *Clin Oral Investig.* 2014;18(1):335–42. DOI: 10.1007/s00784-013-0971-x
- Chai Y, Dong Y, Lu Y, Wei W, Chen M, Yang C. Risk Factors Associated With Inferior Alveolar Nerve Injury After Extraction of Impacted Lower Mandibular Third Molars: A Prospective Cohort Study. *J Oral Maxillofac Surg.* 2024;82(9):1100–8. DOI: 10.1016/j.joms.2024.05.003
- Klatt JC, Sorowka T, Kluwe L, Smeets R, Gosau M, Hanken H. Does a preoperative cone beam CT reduce complication rates in the surgical removal of complex lower third molars? A retrospective study including 486 cases. *Head Face Med.* 2021;17(1):33. DOI: 10.1186/s13005-021-00271-5
- Matzen LH, Wenzel A. Efficacy of CBCT for assessment of impacted mandibular third molars: a review – based on a hierarchical model of evidence. *Dentomaxillofac Radiol.* 2015;44(1):20140189. DOI: 10.1259/dmfr.20140189

- Guerrero ME, Botetano R, Beltran J, Horner K, Jacobs R. Can preoperative imaging help to predict postoperative outcome after wisdom tooth removal? A randomized controlled trial using panoramic radiography versus cone-beam CT. *Clin Oral Investig*. 2014;18(1):335-42. DOI: 10.1007/s00784-013-0971-x
- Santosh P. Impacted mandibular third molars: Review of literature and a proposal of a combined clinical and radiological classification. *Ann Med Health Sci Res*. 2015;5(4):229. DOI: 10.4103/2141-9248.160177
- Almeida-Marques M, Ingold MMS, Da Silva-Junior AF, Franco A, Junqueira JLC, Oenning AC. Panoramic Radiography vs. CBCT in the Evaluation of the Maxillary Third Molar Roots. *Medicina (Mex)*. 2023;59(11):1975. DOI: 10.3390/medicina59111975
- Peralta-Mamani M, Rubira C, López-López J, Honório H, Rubira-Bullen I. CBCT vs panoramic radiography in assessment of impacted upper canine and root resorption of the adjacent teeth: A systematic review and meta-analysis. *J Clin Exp Dent*. 2024;e198-222. DOI: 10.4317/jced.61285
- Del Llano NC, Ribeiro RA, Martins CC, Assis NMSP, Devito KL. Panoramic versus CBCT used to reduce inferior alveolar nerve paresthesia after third molar extractions: a systematic review and meta-analysis. *Dentomaxillofac Radiol*. 2020;49(4):20190265. DOI: 10.1259/dmfr.20190265
- Elkhateeb SM, Awad SS. Accuracy of panoramic radiographic predictor signs in the assessment of proximity of impacted third molars with the mandibular canal. *J Taibah Univ Med Sci*. 2018;13(3):254-61. DOI: 10.1016/j.jtumed.2018.02.006
- Jacobs R, Salmon B, Codari M, Hassan B, Bornstein MM. Cone beam computed tomography in implant dentistry: recommendations for clinical use. *BMC Oral Health*. 2018;18(1):88. DOI: 10.1186/s12903-018-0523-5
- Datta S, Mallick R, Menon S, Sham ME, Kumar V, Archana S. Correlation of Panoramic Radiological and Intra-Operative Findings of Impacted Mandibular 3rd Molar in Relation to Inferior Alveolar Canal: A Prospective Study. *J Maxillofac Oral Surg*. 2021;20(4):689-95. DOI: 10.1007/s12663-020-01410-2
- Ruiz-Roca JA, Rodríguez-Molinero JA, Javaloyes-Vicente P, Pereira-Lopes O, Gay-Escoda C. Use of CBCT and panoramic radiography in the prediction of alterations in sensivity of the inferior alveolar nerve in third molars: A retrospective cross-sectional study. *Saudi Dent J*. 2024;36(8):1105-10. DOI: 10.1016/j.sdentj.2024.06.001
- Pauwels R. Cone beam CT for dental and maxillofacial imaging: dose matters: Table 1. *Radiat Prot Dosimetry*. 2015;165(1-4):156-61. DOI: 10.1093/rpd/ncv057
- Tofangchiha M, Koushaei S, Mortazavi M, Souri Z, Alizadeh A, Patini R. Positive Predictive Value of Panoramic Radiography for Assessment of the Relationship of Impacted Mandibular Third Molars with the Mandibular Canal Based on Cone-Beam Computed Tomography: A Cross-Sectional Study. *Diagnostics*. 2021;11(9):1578. DOI: 10.3390/diagnostics11091578
- Korkmaz YT, Kayıpmaz S, Senel FC, Atasoy KT, Gumrukcu Z. Does additional cone beam computed tomography decrease the risk of inferior alveolar nerve injury in high-risk cases undergoing third molar surgery? Does CBCT decrease the risk of IAN injury? *Int J Oral Maxillofac Surg*. 2017;46(5):628-35. DOI: 10.1016/j.ijom.2017.01.001

- Alsharif SB, Alsharif MB. Patterns of Mandibular Third Molar Impactions and Its Association with Carious Lesions and Periodontal Defects: A Retrospective Cross-Sectional Study. Clin Cosmet Investig Dent. 2025;Volume 17:481-90. DOI: 10.2147/CCIDE.S559569
- Hassan A. Pattern of third molar impaction in a Saudi population. Clin Cosmet Investig Dent. 2010;109. DOI: 10.2147/CCIDEN.S12394

- Winstanley KL, Otway LM, Thompson L, Brook ZH, King N, Koong B, et al. Inferior alveolar nerve injury: Correlation between indicators of risk on panoramic radiographs and the incidence of tooth and mandibular canal contact on cone-beam computed tomography scans in a Western Australian population. J Investig Clin Dent. 2018;9(3):e12323. DOI: 10.1111/jicd.12323

