

# The agreement of panoramic radiography with cone-beam computed tomography in classifying impacted lower third molars: a systematic review

Husni Mubarak<sup>1,2</sup>, Andi Tajrin<sup>1,2</sup>, Nurwaida<sup>1,2</sup>

<sup>1</sup>Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Hasanuddin University, Makassar, Indonesia

<sup>2</sup>Dental Hospital of Hasanuddin University, Makassar, Indonesia

**Background:** This systematic review aimed to determine whether cone-beam computed tomography (CBCT) and panoramic radiography (PR) yield consistent results in determining the degree of impacted lower third molar teeth based on existing classification parameters.

**Methods:** A comprehensive literature search was conducted of PubMed, Embase, Cochrane, and PLOS One, adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Additionally, a manual search was also carried out. There were no restrictions on publication dates, allowing a broader scope of literature. Only articles published in English were eligible for inclusion. Furthermore, all studies that compared the outcomes of CBCT and panoramic images concerning the position of impacted teeth, according to the Winter and the Pell & Gregory classifications, were included.

**Results:** Four studies met the inclusion criteria. One study used the Pell & Gregory classification to assess differences, finding a significant result ( $p < 0.001$ ). Two studies used both the Winter and the Pell & Gregory classifications. In these assessments, one study found no significant differences in the Winter classification ( $p = 1.000$ ) or the Pell & Gregory assessment ( $p = 0.500$ ). However, another study identified significant differences using both the winter and the Pell & Gregory classifications ( $p < 0.001$ ). One study conducted an assessment using only Winter classification and found no significant differences between PR and CBCT ( $p > 0.05$ ).

**Conclusion:** There are inter-modality differences in the agreement concerning the degree of impaction of the third molar when using CBCT compared with panoramic imaging across various classification levels. Improved assessment methods are necessary to determine the most appropriate imaging modality for therapeutic management.

**Abbreviations:** CBCT, cone-beam computed tomography; PR, panoramic radiography; 3D, three dimensional

**Keywords:** Classification / Cone-beam computed tomography / Impacted teeth / Panoramic radiography / Third molar

## INTRODUCTION

The mandibular third molars are among the most commonly

**Correspondence:** Andi Tajrin

Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Hasanuddin University, Jalan Perintis Kemerdekaan Km.10, Makassar 90245, Indonesia  
E-mail: anditajrin@unhas.ac.id

**How to cite this article:**

Mubarak H, Tajrin A, Nurwahida. The agreement of panoramic radiography with cone-beam computed tomography in classifying impacted lower third molars: a systematic review. Arch Craniofac Surg 2024;25(6):263-269. https://doi.org/10.7181/acfs.2024.00304

Received May 29, 2024 / Revised June 24, 2024 / Accepted October 4, 2024

impacted teeth found in dental clinics [1]. Removal of impacted teeth is one of the most frequent procedures performed by oral and maxillofacial surgeons [2]. The appropriate surgical approach should be determined based on the results of a preoperative examination, which evaluates the position of the impacted tooth and its relationship to surrounding structures [3]. An accurate evaluation is crucial for minimizing and managing both intraoperative and postoperative complications [4,5].

Selecting the most appropriate radiographic technique can provide useful information for diagnosis and therapy [6]. Moreover, it is essential to explore imaging modalities that pro-

vide an adequate diagnosis while minimizing radiation exposure [7]. Conventional two-dimensional panoramic radiography (PR) has traditionally served as a primary examination tool for diagnosing dental issues [8]. PR is commonly utilized for initial assessments, helping to evaluate root morphology, the angulation of impacted teeth, and the type of impaction [5]. However, this imaging technique is susceptible to image overlap, magnification, and distortion, particularly in the region of the ascending ramus of the mandible. In addition to PR, cone-beam computed tomography (CBCT) offers superior three-dimensional (3D) assessment of the anatomical relationships between the third molar and surrounding structures. Despite its advantages, CBCT is not commonly used in clinical practice due to its high cost [3].

Various classification systems have been developed to determine the classification of impacted teeth. These systems assess the angulation of the impacted third molar, its relationship to the anterior border of the ramus and the second molar, and the depth of impaction [9]. Among these, the Pell & Gregory and Winter classifications are the most widely used to predict the difficulty of surgical procedures [10]. The Pell & Gregory system categorizes third molars based on their relationship to the ramus of the ascending mandible (specifically, the space available distal to the second molar) and the depth of the impacted tooth within the bone, relative to the occlusal plane. The Winter classification, on the other hand, focuses on the aggregation of impacted third molars.

This systematic review aimed to assess whether panoramic imaging is equivalent to CBCT in determining the degree of impaction of mandibular third molars, according to the two major classification systems established by Winter and Pell & Gregory.

## MATERIALS AND METHODS

This study was carried out in accordance with the widely accepted protocol for Preferred Reporting Items for Systematic Reviews and Meta-Analyses. We conducted an electronic litera-

ture search across multiple databases, including PubMed, PLOS One, Cochrane Library, and Wiley, through September 2021, utilizing a variety of keywords. Table 1 offers a detailed summary of the final search keywords used for each database. Additionally, a manual search of the references from the included studies was carried out to enhance the literature search. No protocol registration was performed.

The study population consisted of patients with impacted mandibular third molars who underwent PR and CBCT imaging. The primary outcomes included diagnostic accuracy based on the classification differences between the imaging modalities, as well as the consistency in localizing impacted mandibular third molars across these modalities. The eligibility criteria aligned with the research question posed in the systematic review: “Is PR equivalent to CBCT in determining the classification of impacted mandibular third molars?”. The inclusion criteria: (1) encompassed various study designs, including observational (excluding case reports), experimental, and diagnostic accuracy studies; (2) without restrictions on publication year; and (3) articles written in English.

Studies identified through electronic and manual searches were independently selected for inclusion by three reviewers (HM, AT, and N) who conducted their assessments blindly. The selection of relevant articles was determined by consensus. Data extraction was performed independently by the same reviewers, who focused on extracting data that addressed specific research questions. The relevance of an article was judged based on its applicability to the subject matter. This validity was assessed by examining information bias, selection methods, and the quality of the analysis. In cases of disagreement among the reviewers, consensus was achieved through joint discussion. In the first step of the process, known as screening, reviewers excluded studies that did not focus on impacted teeth by filtering out irrelevant titles from the search results. In the second step, the reviewer evaluated the abstracts. In the third step, the reviewer examined the full articles, excluding those that did not meet the inclusion criteria. Studies that were unavailable in full-text or had incomplete or unclear data were also excluded.

**Table 1.** Keywords used to search each database

No	Databases	Keywords
1	PubMed	("Cone-Beam Computed Tomography" [Mesh] "Cone-Beam Computed Tomography OR CBCT") and ("Radiography Panoramic" [Mesh] "Radiography Panoramic OR traditional imaging OR panoramic OR 2D image OR two dimensional OR orthopantomogram") and Impacted third Molar and Classification
2	PLOS One	Cone-Beam Computed Tomography OR CBCT and Radiography Panoramic OR traditional imaging OR panoramic OR 2D image OR two dimensional OR orthopantomogram and Impacted third Molar and Classification
3	Cochrane Library	Cone-Beam Computed Tomography OR CBCT and Radiography Panoramic OR traditional imaging OR panoramic OR 2D image OR two dimensional OR orthopantomogram and Impacted third Molar and Classification
4	Wiley	Cone-Beam Computed Tomography OR CBCT and Radiography Panoramic OR traditional imaging OR panoramic OR 2D image OR two dimensional OR orthopantomogram and Impacted third Molar and Classification

The following data were extracted from full-text articles using a data extraction form and recorded in Microsoft Excel 2016: author, year of publication, country or study area, age, gender, and the impaction classification of mandibular third molars according to the Winter and the Pell & Gregory systems, using panoramic imaging and CBCT. The primary outcome of this study was the level of agreement in classifying impacted mandibular third molars using CBCT compared to panoramic radiographs.

The same researcher conducted an independent risk of bias assessment using the Joanna Briggs Institute global appraisal tools. This scale employs a checklist system tailored to the specific study design being evaluated. In this systematic review, three types of checklists are utilized: one for case-control studies, one for cross-sectional studies, and one for cohort studies. Any disagreements are resolved through discussions that include an independent third party.

## RESULTS

Most studies exhibited a high risk of selection bias, and some

cases were challenging to diagnose when comparing different modalities. In the diagnostic test studies, all met the Joanna Briggs Institute criteria requirements: one study achieved 100% compliance [3], while one others met 80% of the criteria [11]. All cohort studies fulfilled the criteria completely [12,13]. The details of the quality assessment according to the Joanna Briggs Institute criteria are presented in Tables 2 and 3.

Fig. 1 illustrates the database search and inclusion criteria. The initial review encompassed 540 articles. After removing duplicates, 484 articles remained. Upon reviewing the titles and abstracts, 21 articles were deemed potentially eligible. Following a full-text evaluation, four of the 21 studies satisfied all inclusion criteria. These studies are listed in Table 4.

The outcome variables of this study were categorized based on CBCT agreement with panoramic imaging, focusing on the relationship to the mandibular ramus (available space), the relationship to the occlusal line, and angulation. Research indicates that the data derived from CBCT differs from that obtained via PR (Table 5). One of the studies included in the review evaluated the relationship with the ramus and occlusal line. Brasil et al. [3] reported significant differences in treatment plans based on

**Table 2.** Critical assessment for the cohort studies included in the review

Question	Freire et al. [12]	Dias et al. [13]
Were the two groups similar and recruited from the same population?	Yes	Yes
Were the exposures measured similarly to assign people to both exposed and unexposed groups?	Yes	Yes
Was the exposure measured in a valid and reliable way?	Yes	Yes
Were confounding factors identified?	Yes	Yes
Were strategies to deal with confounding factors stated?	Yes	Yes
Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	Yes	Yes
Were the outcomes measured in a valid and reliable way?	Yes	Yes
Was the follow up time reported and sufficient to be long enough for outcomes to occur?	Yes	Yes
Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	Yes	Yes
Were strategies to address incomplete follow up utilized?	Yes	Yes
Was appropriate statistical analysis used?	Yes	Yes

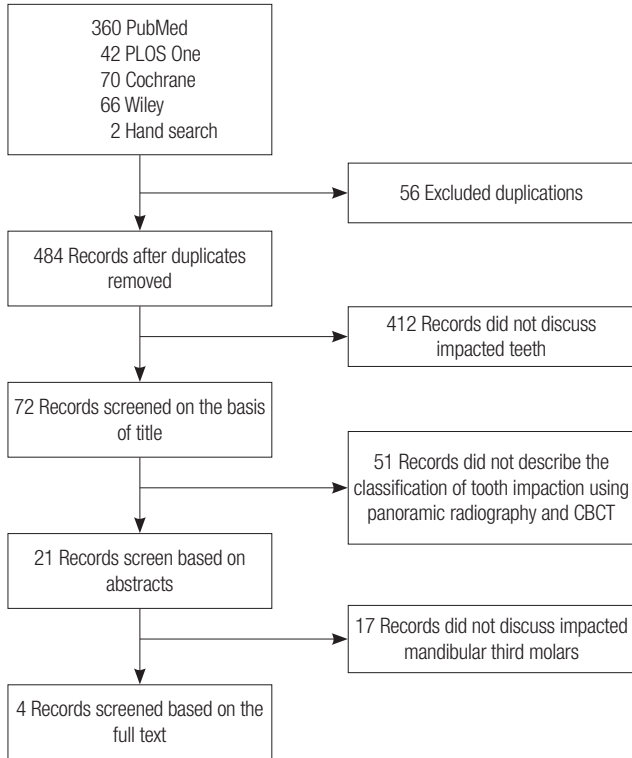
**Table 3.** Critical assessment for the diagnostic studies included in the review

Question	Brasil et al. [3]	Mendonca et al. [11]
Was a consecutive or random sample of patients enrolled?	Yes	Yes
Was a case-control design avoided?	Yes	Yes
Did the study avoid inappropriate exclusions?	Yes	Yes
Were the index test results interpreted without knowledge of the results of the reference standard?	Yes	Yes
If a threshold was used, was it pre-specified?	Yes	No
Is the reference standard likely to correctly classify the target condition?	Yes	Yes
Were the reference standard results interpreted without knowledge of the results of the index test?	Yes	No
Was there an appropriate interval between index test and reference standard?	Yes	Yes
Did all patients receive the same reference standard?	Yes	Yes
Were all patients included in the analysis?	Yes	Yes

the mandibular ramus relationship at 66.8% and the occlusal plane at 79.4% ( $p < 0.001$ ). Two studies assessed tooth position using the Winter and the Pell & Gregory classifications. Freire et al. [12] found that the assessment of angulation yielded the

same diagnosis in PR and CBCT images in all cases (100%,  $p = 1.000$ ). For evaluating the ramus relationship, the agreement was 66.8% ( $p = 0.500$ ), and for the relationship to the occlusal line, it was 79.4% ( $p = 1.000$ ). CBCT identified more cases with sufficient space to accommodate the third molar compared to PR, and the difference was significant [12]. Mendonca et al. [11] observed differences based on the Winter and the Pell & Gregory classifications, with the ramus relationship at 78.3%, the relationship to the occlusal line at 73.7%, and angulation at 77.6%, indicating a significant difference between imaging modalities ( $p < 0.001$ ). One study only conducted an evaluation using the Winter classification; Dias et al. [13] found a difference between PR and CBCT radiographs at 88.4% ( $p > 0.05$ ).

In assessing the suitability between modalities, on all parameters evaluated, results were found to vary between studies. Research conducted by Brasil et al. [3] identified differences in assessments based on the relationship between the mandibular ramus and the occlusal plane. Similar findings were reported in studies by Freire et al. [12] and Mendonca et al. [11], which both utilized the Pell & Gregory classification. These studies noted discrepancies in PR imaging results compared to CBCT, particularly in relation to the mandibular ramus and the occlusal plane. Freire et al., however, found no differences when using the Winter classification for assessment. In contrast, research by Mendonca et al. [11] and Dias et al. [13] revealed differences based on the evaluation of angulation.



**Fig. 1.** Flow diagram. CBCT, cone-beam computed tomography.

**Table 4.** Characteristics of the included studies

Author (year)	Geographic region	Study design	Patients (no. of teeth)	Sex (M:F)	Mean age (yr)	Imaging systems (specifications)	PR assessment	CBCT assessment
Brasil et al. (2019) [3]	Piracicaba, Brazil	Retrospective case-series study	173 (313)	M: 66, F: 107	M: 22.6, F: 23	Panoramic (OPI00D), CBCT (Picasso Trio)	Relationship to the ramus Relationship to the occlusal line	Relationship to the ramus Relationship to the occlusal line
Freire et al. (2019) [12]	Sao Paulo, Brazil	Observational cross-sectional	34	-	-	Panoramic and EBW (Cranex 3D), CBCT (Picasso Trio)	Relationship to the ramus Relationship to the occlusal line Angulation Radiographic signs of proximity detected in the PR and EBW radiographs Anatomical relationship between mandibular third molars and the mandibular canal	Relationship to the ramus Relationship to the occlusal line Angulation Anatomical relationship between mandibular third molars and the mandibular canal
Mendonca et al. (2020) [11]	Sao Paulo, Brazil	Retrospective case-series study	218	-	-	Panoramic (VATECH PaxX-400C), CBCT (i-CAT FLX)	Assessed for ILTM classification Contact with the mandibular canal Contact and resorption of the LSM Intraoperative planning and postoperative expectations	Assessed for ILTM classification Contact with the mandibular canal Contact and resorption of the LSM Intraoperative planning and postoperative expectations
Dias et al. (2020) [13]	Sao Paulo, Brazil	Observational cross-sectional	70 (124)	M: 33, F: 37	25.7	Panoramic (OP200 device), CBCT (i-CAT)	Angulation Absence of bone loss	Angulation Absence of bone loss

PR, panoramic radiography; CBCT, cone-beam computed tomography; EBW, extraoral bitewing; ILTM, impacted lower third molars; LSM, lower second molar.

**Table 5.** Agreement of panoramic radiography with cone-beam computed tomography for impacted mandibular third molars based on the Pell & Gregory and Winter classifications

Author (year)	Classification	Evaluated variable	Result (deal, %)	p-value
Brazil et al. (2019) [3]	Pell & Gregory	Relationship to the ramus	66.8	< 0.001
		Relationship to the occlusal line	79.4	< 0.001
Freire et al. (2019) [12]	Pell & Gregory	Relationship to the ramus	66.8	0.500
		Relationship to the occlusal line	79.4	1.000
	Winter	Angulation	100.0	1.000
Mendonca et al. (2020) [11]	Pell & Gregory	Relationship to the ramus	78.3	< 0.001
		Relationship to the occlusal line	73.7	< 0.001
	Winter	Angulation	77.6	< 0.001
Dias et al. (2020) [13]	Winter	Angulation	88.4	> 0.05

## DISCUSSION

This systematic review analyzed the evidence for diagnostic accuracy in assessing impacted mandibular third molars, using the Winter and the Pell & Gregory classifications, which are currently the most frequently used in therapy planning. The focus was on comparing classifications based on PR versus CBCT imaging. In the preoperative assessment for the extraction of lower third molars, PR is considered the diagnostic standard among imaging examinations of the oral cavity, allowing direct evaluation of the teeth through the anatomical structure of the area [2,14]. Accurately and correctly predicting the position of the third molar can help avoid the risk of complications [15,16].

Our study revealed differences across all assessments that utilized the Pell & Gregory classification. PR, a two-dimensional imaging technique, displayed a range of specific signs [17]. In instances where there was disagreement between imaging modalities, PR often underestimated the available space for accommodating the third molar. This underestimation could be attributed to the overlapping of the mandibular ramus in the evaluated area, resulting in less space than required.

In assessing tooth angulation, it was found that the differences were not significant in determining the position of the impacted tooth. This finding aligns with the study by Hauge Matzen et al. [18], which reported that CBCT did not show a statistically significant difference in the modalities used for assessing tooth angulation. Discrepancies may arise due to the capabilities of CBCT; for instance, regression analysis results have indicated a higher likelihood of a relaxing incision on CBCT changing the results of the Winter classification based on PR [19].

Cederhag et al. [20] noted that the accuracy of panoramic radiographs in evaluating the morphology of third molars is limited. Hauge et al. [18] reported that CBCT offers greater accuracy than PR for identification purposes. Differences in the perceived position of impacted mandibular third molars on PR

and CBCT images can influence the treatment plan proposed by the examiner. One advantage of CBCT over conventional methods is its reliability, as supported by previous studies, which suggest that CBCT reconstruction provides superior reliability and better visualization [21]. Using PR to assess the impaction of the mandibular ramus may not accurately reveal the true position of the teeth and the risk of associated complications; therefore, careful interpretation is required [3].

The limitations of this study stem from the restricted research and data available. It is hypothesized that CBCT may demonstrate superior outcome efficacy in certain cases. However, there is insufficient evidence to definitively claim that 3D imaging is essential and consistently enhances treatment outcomes. Future research should focus on comparing the efficacy of CBCT with that of conventional radiography across various levels of patient complexity. Previous studies have shown that professionals shifted their expectations from anticipating “postoperative complications” to expecting “no postoperative complications” after analyzing CBCT scans. This indicates that more frequent analysis of 3D images could lead professionals to anticipate fewer complications [11]. Further clinical studies are needed to explore the use of CBCT for impacted third molars in the mandibular ramus and their association with potential complications. Such studies should aim to determine if there is a difference in predicting risks compared to those based on PR [3]. Eslami et al. [8], stated that therapeutic efficacy, patient outcome efficacy, and community efficacy are considered strong evidence in the decision-making process regarding the use of imaging.

## CONCLUSION

There are differences between CBCT compared with PR in terms of agreement on the classification of third molar impaction according to the Pell & Gregory and the Winter classifica-

tion systems. Therefore, a more thorough assessment is required to determine the most appropriate imaging modality for planning the treatment of mandibular third molar impaction.

## NOTES

### Conflict of interest

No potential conflict of interest relevant to this article was reported.

### Funding

None.

### ORCID

Husni Mubarak <https://orcid.org/0000-0002-1924-7797>  
 Andi Tajrin <https://orcid.org/0000-0002-4186-7968>  
 Nurwahida <https://orcid.org/0000-0002-5154-8071>

### Author contributions

Conceptualization; Data curation; Formal analysis; Methodology; Project administration; Visualization: Husni Mubarak, Andi Tajrin, Nurwahida. Writing - original draft: Husni Mubarak. Writing - review & editing: Husni Mubarak, Andi Tajrin, Nurwahida. Investigation: Husni Mubarak, Andi Tajrin, Nurwahida. Resources: Husni Mubarak. Software: Husni Mubarak. Supervision: Andi Tajrin, Nurwahida. Validation: Husni Mubarak, Andi Tajrin, Nurwahida.

## REFERENCES

- Ryalat S, AlRyalat SA, Kassob Z, Hassona Y, Al-Shayyab MH, Sawair F. Impaction of lower third molars and their association with age: radiological perspectives. *BMC Oral Health* 2018;18:58.
- Reia VC, de Toledo Telles-Araujo G, Peralta-Mamani M, Biancardi MR, Rubira CM, Rubira-Bullen IR. Diagnostic accuracy of CBCT compared to panoramic radiography in predicting IAN exposure: a systematic review and meta-analysis. *Clin Oral Investig* 2021;25:4721-33.
- Brasil DM, Nascimento EH, Gaeta-Araujo H, Oliveira-Santos C, Maria de Almeida S. Is panoramic imaging equivalent to cone-beam computed tomography for classifying impacted lower third molars? *J Oral Maxillofac Surg* 2019;77:1968-74.
- Stacchi C, Daugela P, Berton F, Lombardi T, Andriulionis T, Perinetti G, et al. A classification for assessing surgical difficulty in the extraction of mandibular impacted third molars: description and clinical validation. *Quintessence Int* 2018;49:745-53.
- Issrani R, Prabhu N, Sghaireen M, Alshubrmi HR, Alanazi AM, Alkhalaf ZA, et al. Comparison of digital OPG and CBCT in assessment of risk factors associated with inferior nerve injury during mandibular third molar surgery. *Diagnostics (Basel)* 2021;11:2282.
- Fragiskos FD. *Oral surgery*. Springer; 2007.
- Bushberg JT. Eleventh annual Warren K. Sinclair keynote address: science, radiation protection and NCRP: building on the past, looking to the future. *Health Phys* 2015;108:115-23.
- Eslami E, Barkhordar H, Abramovitch K, Kim J, Masoud MI. Cone-beam computed tomography vs conventional radiography in visualization of maxillary impacted-canine localization: a systematic review of comparative studies. *Am J Orthod Dentofacial Orthop* 2017;151:248-58.
- Rafetto LK, Synan W. Surgical management of third molars. *Atlas Oral Maxillofac Surg Clin North Am* 2012;20:197-223.
- Khojastepour L, Khaghaninejad MS, Hasanshahi R, Forghani M, Ahrari F. Does the Winter or Pell and Gregory classification system indicate the apical position of impacted mandibular third molars? *J Oral Maxillofac Surg* 2019;77:2222.
- Mendonca LM, Gaeta-Araujo H, Cruvinel PB, Tosin IW, Azenha MR, Ferraz EP, et al. Can diagnostic changes caused by cone beam computed tomography alter the clinical decision in impacted lower third molar treatment plan? *Dentomaxillofac Radiol* 2021;50:20200412.
- Freire BB, Nascimento EH, Vasconcelos KF, Freitas DQ, Haiter-Neto F. Radiologic assessment of mandibular third molars: an ex vivo comparative study of panoramic radiography, extraoral bitewing radiography, and cone beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2019;128:166-75.
- Dias MJ, Franco A, Junqueira JL, Fayad FT, Pereira PH, Oening AC. Marginal bone loss in the second molar related to impacted mandibular third molars: comparison between panoramic images and cone beam computed tomography. *Med Oral Patol Oral Cir Bucal* 2020;25:e395-402.
- Cederhag J, Lundegren N, Alstergren P, Shi XQ, Hellen-Halme K. Evaluation of panoramic radiographs in relation to the mandibular third molar and to incidental findings in an adult population. *Eur J Dent* 2021;15:266-72.
- Hasani A, Ahmadi Moshtaghin F, Roohi P, Rakhshan V. Diagnostic value of cone beam computed tomography and panoramic radiography in predicting mandibular nerve exposure during third molar surgery. *Int J Oral Maxillofac Surg* 2017;46:230-5.
- Guerrero ME, Nackaerts O, Beinsberger J, Horner K, Schoenaers J, Jacobs R, et al. Inferior alveolar nerve sensory disturbance after impacted mandibular third molar evaluation using

- cone beam computed tomography and panoramic radiography: a pilot study. *J Oral Maxillofac Surg* 2012;70:2264-70.
17. Saha N, Kedarnath NS, Singh M. Orthopantomography and cone-beam computed tomography for the relation of inferior alveolar nerve to the impacted mandibular third molars. *Ann Maxillofac Surg* 2019;9:4-9.
  18. Hauge Matzen L, Christensen J, Hintze H, Schou S, Wenzel A. Diagnostic accuracy of panoramic radiography, stereo-scanography and cone beam CT for assessment of mandibular third molars before surgery. *Acta Odontol Scand* 2013;71:1391-8.
  19. Smailiene D, Trakiniene G, Beinoriene A, Tutliene U. Relationship between the position of impacted third molars and external root resorption of adjacent second molars: a retrospective CBCT study. *Medicina (Kaunas)* 2019;55:305.
  20. Cederhag J, Truedsson A, Alstergren P, Shi XQ, Hellen-Halme K. Radiographic imaging in relation to the mandibular third molar: a survey among oral surgeons in Sweden. *Clin Oral Investig* 2022;26:2073-83.
  21. Serrant PS, McIntyre GT, Thomson DJ. Localization of ectopic maxillary canines: is CBCT more accurate than conventional horizontal or vertical parallax? *J Orthod* 2014;41:13-8.