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Impacted mandibular third molars: a comparison of orthopantomography and cone-beam computed tomography imaging in predicting surgical difficulty

Husni Mubarak[1,2], Andi Tajrin[1,2], Mohammad Gazali[1,2], Nurwahida[1,2], Fadhlil Ulum A. Rahman[2,3]

[1]*Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Hasanuddin University, Makassar, Indonesia*
[2]*Dental Hospital of Hasanuddin University, Makassar, Indonesia*
[3]*Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Hasanuddin University, Makassar, Indonesia*

Original Article

Background: This study investigated the predictive value of orthopantomography (OPG) for the difficulty of extracting impacted mandibular third molars, in comparison with cone-beam computed tomography (CBCT).
Methods: In this descriptive quantitative investigation, two oral and maxillofacial radiologists evaluated OPG and three-dimensional CBCT images according to the Pell-Gregory and Winter classifications. The results for the classification were compared using the chi-square test, and the prediction of difficulty was assessed using the Pederson scale, with a significance level of $p<0.05$.
Results: The study included 30 patients (14 men and 16 women), providing a total of 53 samples of impacted mandibular third molars. Of these, 30 (56.6%) were from the right side and 23 (43.4%) from the left. There was a statistically significant difference between the OPG and CBCT images concerning their relation to the mandibular ramus ($p<0.05$). However, evaluations based on occlusal lines and angulation showed no significant differences ($p>0.05$). According to the Pederson scale, significant differences were observed between OPG and CBCT in predicting extraction difficulty ($p<0.05$).
Conclusion: CBCT offered a more accurate assessment of the surgical difficulty associated with mandibular third molars than OPG. OPG views frequently failed to adequately visualize the region of the mandibular ramus, influencing the perceived difficulty of mandibular third molar surgery. In certain cases, the use of CBCT imaging is crucial.

Abbreviations: CBCT, cone-beam computed tomography; CT, computed tomography; ICC, intraclass correlation coefficient; OPG, orthopantomography; 2D, 2-dimensional; 3D, 3-dimensional

Keywords: Cone-beam computed tomography / Impacted teeth / Panoramic / Predicting surgical / Third molars

INTRODUCTION

Radiographic imaging is essential for diagnosing diseases, identifying injuries, and managing patient conditions [1]. Doctors prescribe radiographs when they believe the images will provide valuable diagnostic information that could influence the treatment plan [2]. As a diagnostic tool, radiographs are particularly valuable and important to oral surgeons, providing critical information that significantly aids in diagnosis and therapy [3].

Several types of radiographs are used in dentistry, each designed to help dentists view different areas of the mouth through two-dimensional (2D) and three-dimensional (3D) imaging [4]. Until recently, OPG imaging was the preferred

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

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method in Europe for evaluating impacted mandibular third molars, assisting surgeons in their diagnostic and treatment decisions [5,6]. However, this 2D imaging technique is prone to issues such as image overlap, magnification, and distortion, especially in the ascending mandibular ramus region [2,7]. Given the limitations of 2D radiography, which has been a cornerstone of diagnostic imaging for decades, it is likely that its use will diminish in the future [8].

3D imaging is evolving to meet the demands of advanced technology in delivering treatment and is simultaneously driving the development of new treatment strategies [9]. Cone-beam computed tomography (CBCT) systems represent a variation of traditional computed tomography (CT) systems, which were developed in the 1990s in response to the demand for 3D information that conventional CT scans could not provide [10]. In dentistry, CBCT is increasingly used as a diagnostic tool, especially in the field of oral and maxillofacial surgery, where it offers superior sectional views that more accurately depict anatomical landmarks [11]. Additionally, CBCT scans can be analyzed using modern CT software, facilitating comprehensive dynamic assessments before surgery [12]. Compared to conventional imaging techniques, CBCT technology reduces exposure by using a lower radiation dose [10].

Continuing technological advancements have facilitated improvements in the planning processes for therapeutic procedures. However, as technology progresses, the associated costs have also risen, leading healthcare systems with limited resources to consider simpler imaging techniques for establishing disease diagnoses. Although orthopantomography (OPG) is regarded as the gold standard, CBCT may offer more accurate predictions. This raises the question: is OPG truly the gold standard for predicting the difficulty of impacted mandibular third molar surgery? In developing countries, diagnoses are frequently made using OPG rather than CT. However, to ensure more accurate treatments, the wider dissemination of CT technology is necessary.

We conducted this study to assess the correlation between OPG and CBCT imaging, utilizing the Pell-Gregory and Winter parameters to identify the location of impacted mandibular third molars. The findings of this study can be used to evaluate the predictive value of OPG in the extraction of impacted mandibular third molars.

METHODS

Research ethics

This is a descriptive quantitative study that utilizes an analytic observational method and a cross-sectional study design. The study received approval from the Dental Research Ethics Agency of Hasanuddin University under approval number 0110/PL.09/KEPK-RSGM UNHAS/2020, with Protocol Number UH 17120395 on November 30, 2020.

Data collection

All patients who visited the oral and maxillofacial surgery clinic at Hasanuddin University Dental Hospital between November 2020 and November 2021 with complaints of impacted mandibular third molars were considered for this study. The accidental sampling method was employed to select the research subjects. This method was chosen because it allows for quick and easy completion of the research. Sampling was based on incidental encounters with individuals who met the inclusion criteria: (1) the presence of impacted lower third molars, with either one or two impacted teeth; (2) age of at least 21 years; and (3) willingness to participate in the research. The exclusion criteria were as follows: (1) absence of the second molar adjacent to the impacted tooth, or a broken crown on the second molar; (2) presence of a severe injury, such as a bone or tooth fracture; and (3) presence of a lesion or tumor around the impacted tooth.

Image interpretation

Using the X Mind Pano D+Ceph type for OPG and the Vatech type for CBCT, measurements were taken from panoramic images on OPG and 3D dental mode sagittal images from CBCT, with image capture performed by the same operator. The assessment was carried out by three expert raters in oral and maxillofacial radiology, who had previously agreed on a common approach to evaluating OPG and CBCT images. This method modifies the evaluation criteria of the Pell-Gregory (Table 1) and Winter classifications (Table 2). For OPG, image interpretation was conducted using 3D Slicer software. In the case of CBCT, the Ezdent-i program was utilized, focusing on measurements related to the mandibular ramus, occlusal lines, and angle. The preoperative difficulty of impacted mandibular third molars is assessed using the Pederson scale (Table 3) [13]. This scale affects the evaluation of the Pell-Gregory and Winter classifications [14-17].

Statistical analysis

Data analysis was conducted using SPSS software version 25 (IBM Corp.), with results reported as frequencies and percentages. The findings from OPG and CBCT were compared using the chi-square test, with a significance level set at $p<0.05$. Image interpretation was performed by two experienced evaluators, each within their respective disciplines. The consistency of

Table 1. Parameters considered in the Pell-Gregory classification [3,7,18]

Parameter	Description
Relationship with the ramus of the mandible	
Class I	Sufficient distance from the second molar's ascending and distal ramus to the third molar's diameter
Class II	The space between the ascending and distal ramus of the second molar is smaller than the crown diameter of the third molar
Class III	All or most of the third molar is in the ramus
Relationship to the occlusal line	
A position	The highest occlusal surface of the impacted tooth is parallel to or higher than the occlusal surface of the second molar
B position	The highest occlusal surface of the impacted tooth is parallel to or higher than the cervical line of the second molar
C Position	The highest occlusal surface of the impacted tooth is parallel to or below the cervical line of the second molar

Table 2. Parameters considered in the Winter classification [3,15,19-21]

Parameter	Description
Mesioangular	Impacted teeth are tilted toward the second molar/mesially (11° to 79°)
Distoangular	The long axis of the third molar is tilted distally or posteriorly away from the second molar (–11° to –79°)
Vertical	The long axis of the third molar is parallel to the long axis of the second molar (0° to 10°)
Horizontal	The long axis of the third molar is horizontal (80° to 100°)

Table 3. Pederson scale for predicting the degree of difficulty with impacted mandibular third molars [13,22,23]

Criteria	Mark
Molar tooth position	
Mesioangular	1
Horizontal	2
Vertical	3
Distoangular	4
Relationship with ramus and available space	
Class I	1
Class II	2
Class III	3
Relative depth	
A position	1
B position	2
C position	3

Table 4. Demographic data of the research sample (n=53)

Sex	Region, No. (%)		No. (%)	Age (yr), mean ± SD
	Right	Left		
Men	14 (26.5)	9 (16.9)	23 (43.4)	28.3 ± 4.3
Women	16 (30.2)	14 (26.4)	30 (56.6)	28.2 ± 6.8

SD, standard deviation.

measurements made on 3D OPG and CBCT images was confirmed using the intraclass correlation coefficient (ICC).

RESULTS

The characteristics of the final sample are detailed in Table 4. Between November 2021 and November 2022, 567 patients with impacted mandibular third molars sought treatment at the oral surgery clinic. Of these, 537 were excluded from the study due to various reasons, such as refusal to participate, lesions in the crown region, or partial crown loss on the impacted teeth. Ultimately, 30 patients who met the inclusion criteria were selected for the study. This group comprised 14 male (47%) and 16 female (53%) patients, providing a total of 53 impacted lower third molars. Among the male patients, 14 samples (26.5%) were taken from the right side and nine (16.9%) from the left. For female patients, 16 samples (30.2%) of impacted mandibular third molars were from the right side and 14 (26.4%) from the left.

A comparison of the two imaging modalities for evaluating impacted teeth adjacent to the mandibular ramus showed discrepancies according to the Pell-Gregory classification. In class 1, the incidence was 5.7% with OPG and 49.1% with CBCT. For class 2, OPG showed an incidence of 83%, compared to 50.9% with CBCT. In class 3, OPG recorded 11.3%, while CBCT did not record any cases in this class (Table 5). There was a statistically significant difference between OPG and CBCT in imaging the mandibular ramus ($p < 0.05$). In terms of the occlusal line, position A was recorded at 30.2% with OPG and 34% with CBCT, showing a slight disparity. Position B was observed in 47.1% of OPG images and 43.3% of CBCT images. For position C, no significant difference was noted (Table 5). Overall, there was no statistically significant difference between OPG and CBCT concerning the occlusal line ($p > 0.05$).

OPG and CBCT imaging revealed numerous discrepancies in evaluating impacted tooth angulation according to Winter's classification. The results showed that horizontal angulation was 20.8% for OPG and 22.6% for CBCT. For vertical angulation, the figures were 13.2% for OPG and 15.1% for CBCT. Distoangular angulation was 13.2% with OPG and 9.0% with

Table 5. Comparison between OPG and CBCT in the evaluation of impacted mandibular third molars according to the Pell and Gregory classification

Classification	Mandibular ramus				Occlusal line			
	I	II	III	*p*-value	A	B	C	*p*-value
OPG	3 (5.7)	44 (83.0)	6 (11.3)	0.000[a]	16 (30.2)	25 (47.1)	12 (22.6)	0.986
3D CBCT	26 (49.1)	27 (50.9)	0		18 (34.0)	23 (43.3)	12 (22.6)	

Values are presented as number (%). Numbers are the number of impacted mandibular third molars.
OPG, orthopantomography; CBCT, cone-beam computed tomography; 3D, three-dimensional.
[a]$p<0.05$ using the chi-square test.

Table 6. Comparison between OPG and CBCT in the evaluation of impacted mandibular molars according to Winter's classification

Classification	Angulation				*p*-value
	M	H	V	D	
OPG	28 (52.8)	11 (20.8)	7 (13.2)	7 (13.2)	0.996
3D CBCT	28 (52.8)	12 (22.6)	8 (15.1)	5 (9.4)	

Values are presented as number (%). Numbers are the number of impacted mandibular third molars.
OPG, orthopantomography; CBCT, cone-beam computed tomography; 3D, three-dimensional.

Table 7. Comparison between OPG and CBCT in the evaluation of difficulty prediction based on Pederson's assessment

Classification	Predictions			*p*-value
	Easy	Moderate	Difficult	
OPG	4 (7.5)	29 (54.7)	20 (37.7)	0.003[a]
3D CBCT	12 (22.6)	34 (64.2)	7 (13.2)	

Values are presented as number (%). Numbers are the number of impacted mandibular third molars.
OPG, orthopantomography; CBCT, cone-beam computed tomography; 3D, three-dimensional.
[a]$p<0.05$ using the chi-square test.

CBCT. There was no difference in the mesioangular position (Table 6). The classification of impacted lower third molars did not significantly change in relation to angulation ($p>0.05$).

The predicted difficulty of impacted mandibular third molar surgery according to the Pederson scale is presented in Table 7. The results from a basic examination showed 7.5% for OPG and 22.6% for CBCT. The evaluations rated 54.7% of OPG and 64.0% of CBCT as moderate; 37.7% of OPG and 13.2% of CBCT as difficult. Statistical analysis indicated that the predictions of difficulty levels for impacted mandibular third molar surgery significantly differed ($p<0.05$). This variation can influence the treatment plan when OPG and CBCT are utilized as supplementary examination modalities.

Based on the ICC results, the two assessors concurred in measuring the distance from the mandibular ramus to the impacted mandibular third molar using OPG ($\kappa=0.833$) and CBCT ($\kappa=0.962$). They also agreed on the occlusal depth of the impacted mandibular third molar using both OPG ($\kappa=1.000$) and CBCT ($\kappa=1.000$). Similarly, there was consensus on the angulation of the impacted mandibular third molar teeth with OPG ($\kappa=1.000$) and CBCT ($\kappa=1.000$). Regarding the level of difficulty, both raters were in agreement when using OPG ($\kappa=0.902$) and CBCT ($\kappa=0.963$).

DISCUSSION

The efficacy of therapy, patient outcomes, and community success are considered solid evidence when selecting radiography modalities [24]. The ability to predict surgical difficulties before removing an impacted mandibular third molar allows for the development of a treatment plan that minimizes the risk of complications [14]. The Pederson scale modifies the Pell-Gregory categorization, and Winter has been shown to predict both simple and complex surgical difficulties [18]. Pederson's evaluation assesses differences related to the mandibular ramus, influencing the treatment plan and anticipated outcomes based on the expected level of intraoperative difficulty [14]. Previous studies have shown that CBCT analysis can reduce postoperative complications [25].

In our study, we found a statistically significant difference in the measurements of the mandibular ramus. The results from the OPG measurements influenced the classification (1-3) of impacted teeth in relation to the mandibular ramus, potentially improving the evaluation of complexity in Pederson's score due to the smaller spaces involved. OPG provides a less accurate representation of the boundaries of the third molar space compared to CBCT, as highlighted by several previous studies [26]. The limitations of conventional imaging techniques often result in the superimposition of the mandibular ascending ramus over the third molar space, even though sufficient space exists in the retromolar area. In OPG images, the oblique ridge usually appears posterior to the anterior border of the ascending ramus, extending from it [7]. Furthermore, OPG radiographs are unable to capture the contour of the dental arch, and the 2D nature of the images may distort the depiction of anatomical structures, leading to potential superimposition. These findings underscore the accuracy of 3D CBCT images in representing the mandibular anatomy of patients [8].

OPG images and 3D teeth mode images from CBCT showed minimal differences in evaluating impaction with respect to the occlusal relationship of the impacted tooth's location. This finding is supported by a study conducted by Brasil et al. in 2019 [7]. The classification according to Pell and Gregory concerning the occlusal plane showed little variation. Devlin and Yuan [27] attribute these results to distortion and image enlargement of the lower vertical component in OPG. Tang et al. [28] found that comparing digital OPG radiography with CBCT images of the mandible revealed a strong correlation between the outcomes of vertical plane measurements on OPG imaging and CBCT ($p \leq 0.05$).

There were also changes in angulation, although these were not statistically significant. This finding aligns with previous research, which has shown that both methods of measuring tooth angulation produce similar results [25,29,30]. In this study, variations in vertical and distal angulation were observed. Multiple studies have indicated that standard OPG tends to project the roots of the mandibular teeth more mesially than their actual positions; thus, this limitation must be considered when assessing root angulation or OPG characteristics [31].

The advantages of CBCT's 3D imaging are particularly notable in the examination of impacted teeth [30]. However, it is important to remember that this technique involves radiation exposure. The ALADA principle, which stands for "as low as diagnostically acceptable," underscores the importance of optimizing radiation exposure in medical imaging. This approach aims to keep radiation levels as low as possible while still obtaining images that are diagnostically useful [32]. The efficacy of CBCT in assessing the complexity of lower third molars has not been extensively studied. Consequently, this method cannot be routinely recommended for planning the extraction of third molars. Brasil et al. [7] suggested using CBCT to identify impacted mandibular third molars only when absolutely necessary; thus, low-dose radiographic techniques (such as conventional radiography) continue to be the preferred approach.

This study further demonstrated that OPG and CBCT yield distinct imaging results. According to numerous studies, Pederson's evaluation, which relies on the Pell-Gregory and Winter's classification, remains inaccurate in assessing the difficulty of third molar extractions and the potential for complications [15]. Future research should evaluate the benefits of CBCT and conventional radiography in patients with different levels of complexity to better estimate the risk of postoperative complications.

Although we observed a significant difference in the assessment, there is insufficient evidence to conclude that 3D imaging is necessary or consistently improves treatment outcomes. The small sample size limits the study's scope. Additionally, samples taken unintentionally may not accurately reflect the population's variation, preventing the generalization of the study results to the broader population. Furthermore, this method is susceptible to bias, as researchers might preferentially select samples that are visually striking or more accessible, resulting in a sample that does not adequately represent population variations. These limitations could lead to errors in the data analysis conducted by researchers.

Venkatesh and Elluru [9] identified therapeutic efficacy, patient outcome efficacy, and community efficacy as strong evidence in the decision-making process for using imaging. Future studies should compare the efficacy of CBCT with that of conventional radiography in patients exhibiting varying levels of complexity. Therefore, additional research is needed to evaluate the complexity level and its association with potential complications following retraction. This research will help determine if there are differences in the use of CBCT compared to OPG in the treatment of lower third molar impaction.

Based on angulation and occlusal angle, similar results were obtained from OPG and CBCT images. However, the majority of OPG images overlooked the mandibular ramus region, which could impact the prediction of the difficulty associated with lower third molar surgery. CBCT offers a more accurate assessment in predicting the surgical difficulty of impacted mandibular third molars compared to OPG. Therefore, in certain cases, it is crucial to consider the use of CBCT imaging.

NOTES

Conflict of interest

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

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None.

Ethical approval

The study received approval from the Dental Hospital of Hasanuddin University (0110/PL.09/KEPK-RSGM UNHAS/2020, with Protocol Number UH 17120395 on November 30, 2020). Informed consent was obtained.

ORCID

Husni Mubarak https://orcid.org/0000-0002-1924-7797
Andi Tajrin https://orcid.org/0000-0002-4186-7968
Mohammad Gazali https://orcid.org/0009-0006-9839-8361
Nurwahida https://orcid.org/0000-0002-5154-8071

Fadhlil Ulum A. Rahman
https://orcid.org/0000-0002-5857-6294

Author contributions

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

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