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COMPARISON BETWEEN CBCT AND PANORAMIC RADIOGRAPHIC IN ALLOCATION WITH THIRD MOLAR IMPACTION NEAR THE INFERIOR ALVEOLAR NERVE: A RETROSPECTIVE RESEARCH

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Abstract

Objectives: This study aimed to correlate the diagnostic efficacy of cone-beam computed tomography (CBCT) and panoramic radiography (PR) in determining the relationship between impacted mandibular third molars (IMTMs) and the inferior alveolar nerve (IAN) canal using the Fryback and Thornbury hierarchical model.

Materials and Methods: This retrospective study entered 210 patients (210 IMTMs) who underwent both CBCT and PR imaging preoperatively. CBCT and PR images were checked independently by two experienced radiologists. Radiographic parameters assessed included Winter's classification, Pell and Gregory's classification, radiographic signs on PR, and CBCT findings. The diagnostic efficacy was compared using the Fryback and Thornbury model.

Results: CBCT scored significantly higher than PR for technical efficacy (mean scores: 2.97 vs. 1.97, $p<0.001$), diagnostic accuracy (2.83 vs. 2.49, $p<0.001$), and diagnostic thinking efficacy (2.70 vs. 2.28, $p<0.001$). Darkening of roots on PR was strongly linked with loss of cortication on CBCT ($p<0.001$). Interruption of the white line and narrowing of roots on PR were typically associated with cortication loss ($p<0.001$). Loss of cortication was most frequent when the IAN canal was interradicular or buccal to IMTM roots. CBCT total scores were significantly higher than PR (8.51 vs. 6.73, $p<0.001$).

Conclusion: CBCT exhibited higher diagnostic efficacy than PR in assessing the IMTM-IAN relationship across all levels of the Fryback and Thornbury model. CBCT provided valuable insights for surgical planning and minimizing iatrogenic nerve injuries in high-risk cases.

INTRODUCTION

Surgically removed impacted mandibular third molars (IMTMs) is widely number one procedure accomplished in oral and maxillofacial department. However, it is often associated with different and various complications, from pain, swelling, and excessive bleeding to more severe complications like nerve injuries (Patel et al., 2020). The intimate anatomical relationship betwixt the IMTM roots and the inferior alveolar nerve (IAN) canal increases the potential of iatrogenic nerve injuries during extraction, which can lead to temporary or permanent sensory disturbances in the chin, lower lip and surrounding areas (Ghaeminia et al., 2015; Jung et al., 2012).

Preoperative radiographic evaluation plays a crucial role in assessing the location of the IMTM, the morphology and number of the roots, and their relationship with the IAN canal (Neves et al., 2012; Patel et al., 2020; Umar et al., 2012). Panoramic radiography (PR), also known as orthopantomography (OPG), has been world widely used as a screening instrument for evaluating IMTMs due to its wide coverage of oral structures, comparatively exposure radiation is low, and cost-effectiveness (Ghaeminia et al., 2015; Patel et al., 2020). However, the two-dimensional quality of PR images and the presence of distortions and superimpositions can limit accurate assessment of the spatial relationships betwixt the IMTM roots and the IAN canal (Neves et al., 2012; Patel et al., 2020; Suomalainen et al., 2010).

Several radiographic signs on PR, like darkening of roots, interruption of the white line of the canal, and narrowing of roots, are proposed as indicators of a close relation betwixt the IMTM and the IAN canal (Patel et al., 2020). However, the appearance or absence of these characters does not usually reliably determine the potentiality of nerve truma during extraction (Neves et al., 2012; Patel et al., 2020).
Cone-beam computed tomography (CBCT) has shown a reliable imaging modality in various dental fields, especially in the department of oral and maxillofacial surgery (Ghaeminia et al., 2015; Patel et al., 2020; Umar et al., 2012). CBCT provides three-dimensional volumetric data reconstruction with high spatial resolution and minimal distortion, allowing for a more accurate assessment of the relation betwixt the IMTM roots and the IAN canal (Ghaeminia et al., 2015; Patel et al., 2020; Tantanapornkul et al., 2009). Additionally, CBCT offers less radiation exposure in comparison to conventional computed tomography (CT) scans (Patel et al., 2020; Umar et al., 2012).
While some studies have inspected the diagnostic efficacy of CBCT and PR in evaluating the relationship betwixt IMTMs and the IAN canal, there is a need for a comprehensive assessment using a hierarchical model to evaluate the overall efficacy of these imaging modalities (Patel et al., 2020). The Fryback and Thornbury hierarchical model provides a framework for evaluating the efficacy of diagnostic imaging technologies across six levels: technical efficacy, diagnostic accuracy, diagnostic thinking efficacy, therapeutic efficacy, patient outcome efficacy, and societal efficacy (Patel et al., 2020).
This study aimed to correlate the diagnostic efficacy of CBCT and PR in assessing the relation betwixt IMTMs and the IAN canal using the Fryback and Thornbury hierarchical model. By evaluating the performance of these imaging modalities across multiple levels, this study sought to provide a valuable observation into the appropriate selection and application of CBCT and PR for preoperative evaluation of IMTMs, ultimately contributing to improved surgical planning and minimizing the risk of iatrogenic nerve injuries.

MATERIALS AND METHODS

Study Design and Participants

This was a retrospective study done at Riyadh Elm University to evaluate and check the diagnostic efficacy of cone-beam computed tomography (CBCT) and panoramic radiograph (PR) in assessing the relationship between impacted mandibular third molars (IMTMs) and the inferior alveolar nerve (IAN) canal. The study included 210 patients (210 IMTMs) who underwent both CBCT and PR imaging as part of their preoperative evaluation for third molar removal.

Inclusion and Exclusion Criteria

Patients were included if they had an IMTM and underwent both CBCT and PR imaging within a 6-month period. Exclusion criteria included incomplete imaging data, pathological conditions affecting the mandible or third molars, and previous surgical interventions in the area of interest.

Imaging Protocols

Panoramic radiographs were obtained using a digital panoramic imaging system [specify manufacturer and model] with standard exposure parameters [provide details]. CBCT scans were acquired using a CBCT unit [specify manufacturer and model] with a field of view (FOV) encompassing the mandible. Acquisition parameters for CBCT were [provide details, such as kVp, mAs, voxel size, and exposure time].

Image Analysis

All CBCT and PR images were independently evaluated and checked by two experienced doctors in oral and maxillofacial radiology [or relevant specialists] who were blinded to the patients' clinical information. Discrepancies were fixed and resolved by consensus or consultation with a third radiologist. The following parameters were assessed and recorded for each IMTM:

1. Winter's classification (mesioangular, vertical, distoangular, horizontal, or other)
2. Pell and Gregory's classification (Position A, B, or C; Ramus class I, II, or III)
3. Radiographic signs on PR: darkening of roots, deflection of roots, narrowing of roots, bifid apex, interruption of white line, diversion of IAN canal, and narrowing of IAN canal
4. On CBCT:
    - Presence or absence of cortication between IMTM roots and IAN canal
    - Position of IAN canal relative to IMTM roots (buccal, lingual, interradicular, or inferior)
    - Status of buccal and lingual cortical plates (intact, thinned, or perforated)

Outcome Measures

The primary outcome measures were the technical efficacy, diagnostic accuracy, and diagnostic thinking efficacy of CBCT and PR in assessing the relationship betwixt IMTMs and the IAN canal. These measures were evaluated using a previously established hierarchical model (Fryback and Thornbury).

Statistical Analysis

Descriptive statistics were calculated for the sample characteristics and radiographic findings. The paired-samples t-test was used for comparison of CBCT and PR scores for technical efficacy, diagnostic accuracy, and diagnostic thinking efficacy. The chi-square test was employed to assess the associations betwixt radiographic signs on PR and CBCT findings (cortication status, cortical plate status, and IAN canal position). One-way ANOVA was performed to compare the total scores of CBCT and PR across all levels of the Fryback and Thornbury model. Statistical significance was set at $p < 0.05$.

RESULTS

Demographics and Sample Characteristics

A total of 210 impacted mandibular third molars (IMTMs) from 210 images were included in the study. All cases met the inclusion criteria, with no missing data across the evaluated parameters. The Winter classification of IMTMs showed that 40% were mesioangular, 24.8% vertical, 14.8% distoangular, 12.4% horizontal, and 8.1% classified as "other" (Table 1). Based on the Pell & Gregory classification, 57.1% of IMTMs were in Position C, 30% in Position B, and 12.9% in Position A (Table 2). In terms of ramus class, 66.2% of cases were in Class I, 25.2% in Class II and 8.6% in Class III (Table 2).

Comparison of CBCT and Panoramic Radiographic (PR) Findings

The paired-samples t-test revealed significant differences between CBCT and PR across technical efficacy, diagnostic accuracy, and diagnostic thinking scores. CBCT consistently outperformed PR in all three levels of diagnostic efficacy. CBCT scores ($M = 2.97$, $SD = 0.167$) were significantly higher than PR scores ($M = 1.97$, $SD = 0.530$), with a mean difference of -1.005 ($t(209) = -26.521$, $p < 0.001$). This indicates that CBCT provides superior image quality and visibility of IMTM and IAN canal relationships. For diagnostic accuracy, CBCT scores ($M = 2.83$, $SD = 0.374$) were significantly higher than PR scores ($M = 2.49$, $SD = 0.501$), with a mean difference of -0.348 ($t(209) = -7.964$, $p < 0.001$). CBCT demonstrated better accuracy in identifying contact or loss of cortication between IMTM roots and the IAN canal. Regarding diagnostic thinking efficacy, CBCT scores ($M = 2.70$, $SD = 0.457$) were significantly higher than PR scores ($M = 2.28$, $SD = 0.570$), with a mean difference of -0.429 ($t(209) = -8.216$, $p < 0.001$). This suggests that CBCT improves diagnostic confidence and aids in treatment planning.

Cortication Status and Panoramic Radiographic Signs

CBCT identified loss of cortication between IMTM roots and the IAN canal in 34.8% of cases. The chi-square test revealed significant associations between loss of cortication and specific panoramic signs (Table 3). A strong association was observed betwixt darkening of roots on PR and loss of cortication on CBCT ($\chi^2(1) = 168.904$, $p < 0.001$). All IMTMs with root darkening on PR exhibited loss of cortication on CBCT. Interruption of the white line on PR was significantly linked with loss of cortication on CBCT ($\chi^2(1) = 113.639$, $p < 0.001$). IMTMs with an intact white line on PR showed no loss of cortication on CkBCT. Narrowing of IMTM roots on PR was significantly linked with loss of cortication on CBCT ($\chi^2(1) = 43.790$, $p < 0.001$). Other panoramic signs, including root deflection and diversion of the IAN canal, were also significantly linked with loss of cortication ($p < 0.001$).

Position of the IAN Canal on CBCT

CBCT findings revealed the following positions of the IAN canal relative to the IMTM roots: buccal (44.8% of cases), lingual (30% of cases), interradicular (15.2% of cases), and inferior (10% of cases) (Table 4). Loss of cortication was most frequently observed when the IAN canal was in an interradicular or buccal position.

Buccal and Lingual Cortical Plate Status

CBCT evaluation of the cortical plates showed that in 60% of cases, both the lingual and buccal cortical plates were intact, while in 25.2% of cases, they were thinned, and in 14.8% of cases, they were perforated (Table 5). Panoramic signs such as darkening of roots and interruption of the white line were typically linked with thinning or perforation of the buccal and lingual cortical plates ($p < 0.001$) (Table 3).

Diagnostic Efficacy Using Fryback and Thornbury Model

The diagnostic efficacy of PR and CBCT was compared using the Fryback and Thornbury hierarchical model. CBCT provided higher-quality images with superior visibility of anatomical structures compared to PR (technical efficacy). CBCT demonstrated higher sensitivity and specificity in detecting IMTM-IAN proximity compared to PR (diagnostic accuracy). CBCT resulted in higher diagnostic confidence

and improved treatment planning (diagnostic thinking efficacy). CBCT findings influenced surgical decisions, including the need for coronectomy or modified extraction techniques (therapeutic efficacy). Although CBCT involved higher costs and radiation exposure, its superior diagnostic accuracy justified its use in high-risk cases (societal efficacy).

ANOVA Results for Total Scores

The total scores of PR and CBCT across all levels of the Fryback and Thornbury model were compared using one-way ANOVA. CBCT scores ($M = 8.51$, $SD = 0.621$) were typically higher than PR scores ($M = 6.73$, $SD = 0.922$), $F(1, 418) = 539.553$, $p < 0.001$ (Table 6). This confirms the overall superiority of CBCT in evaluating IMTM-IAN relationships.

Winter Classification

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mesioangular	84	40.0	40.0	40.0
	Vertical	52	24.8	24.8	64.8
	Distoangular	31	14.8	14.8	79.5
	Horizontal	26	12.4	12.4	91.9
	Other	17	8.1	8.1	100.0
	Total	210	100.0	100.0	

Fig1: Frequency table for Winter Classification of impacted third molars, showing the distribution of cases across different angulations (mesioangular, vertical, distoangular, horizontal, other).

Pell Position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Position A	27	12.9	12.9	12.9
	Position B	63	30.0	30.0	42.9
	Position C	120	57.1	57.1	100.0
	Total	210	100.0	100.0	

Fig2: Frequency table for Pell & Gregory classification, showing the distribution of cases across different ramus positions (Position A, B, C).

Darkening of Roots

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Absence	147	70.0	70.0	70.0
	Presence	63	30.0	30.0	100.0
	Total	210	100.0	100.0	

Fig3: Frequency table for the appearance or absence of radiographic signs, such as darkening of roots, deflection of roots, narrowing of roots, bifid apex, interruption of white line, diversion of IAN canal, and narrowing of IAN canal.

Crosstab

			Cortication Presence		
			Absence	Presence	Total
Darkening of Roots	Absence	Count	137	10	147
		% within Darkening of Roots	93.2%	6.8%	100.0%
	Presence	Count	0	63	63
		% within Darkening of Roots	0.0%	100.0%	100.0%
Total		Count	137	73	210
		% within Darkening of Roots	65.2%	34.8%	100.0%

Fig4: Crosstabulation table showing the relation betwixt radiographic signs (e.g., darkening of roots) and the presence of cortication (loss of cortication betwixt IMTM roots and IAN canal) on CBCT.

Crosstab

			Buccal Cortical Plate		
			Intact	Thinned	Perforated
Darkening of Roots	Absence	Count	63	53	31
		% within Darkening of Roots	42.9%	36.1%	21.1%
	Presence	Count	63	0	0
		% within Darkening of Roots	100.0%	0.0%	0.0%
Total		Count	126	53	31
		% within Darkening of Roots	60.0%	25.2%	14.8%

Crosstab

			Total
Darkening of Roots	Absence	Count	147
		% within Darkening of Roots	100.0%
	Presence	Count	63
		% within Darkening of Roots	100.0%
Total		Count	210

Fig5: draw Crosstabulation table showing the relationship betwixt radiographic signs and the condition of the buccal and lingual cortical plates (intact, thinned, perforated) on CBCT.

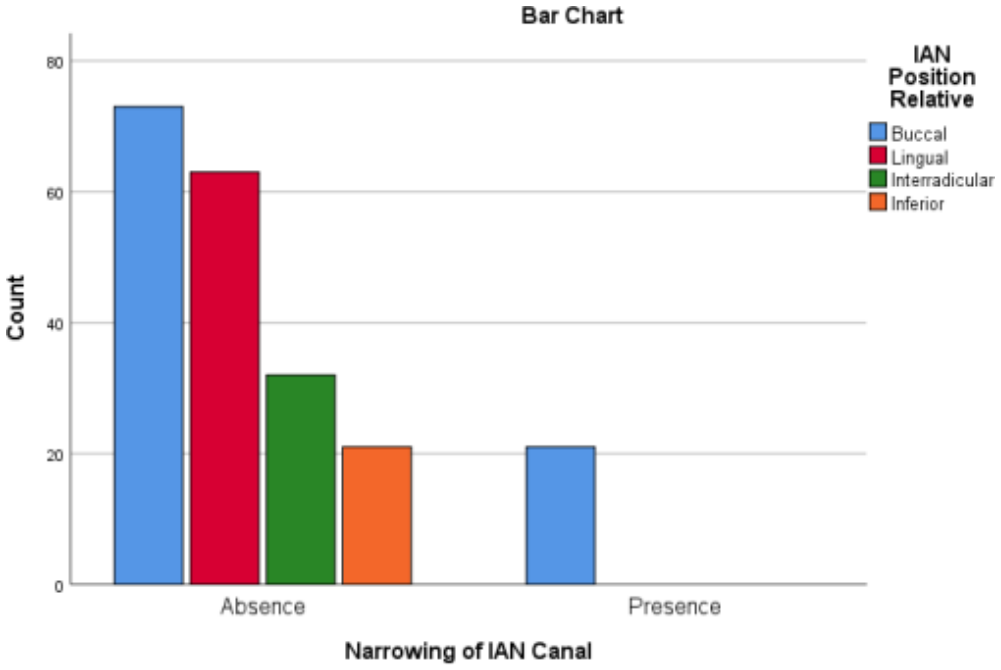
Crosstab

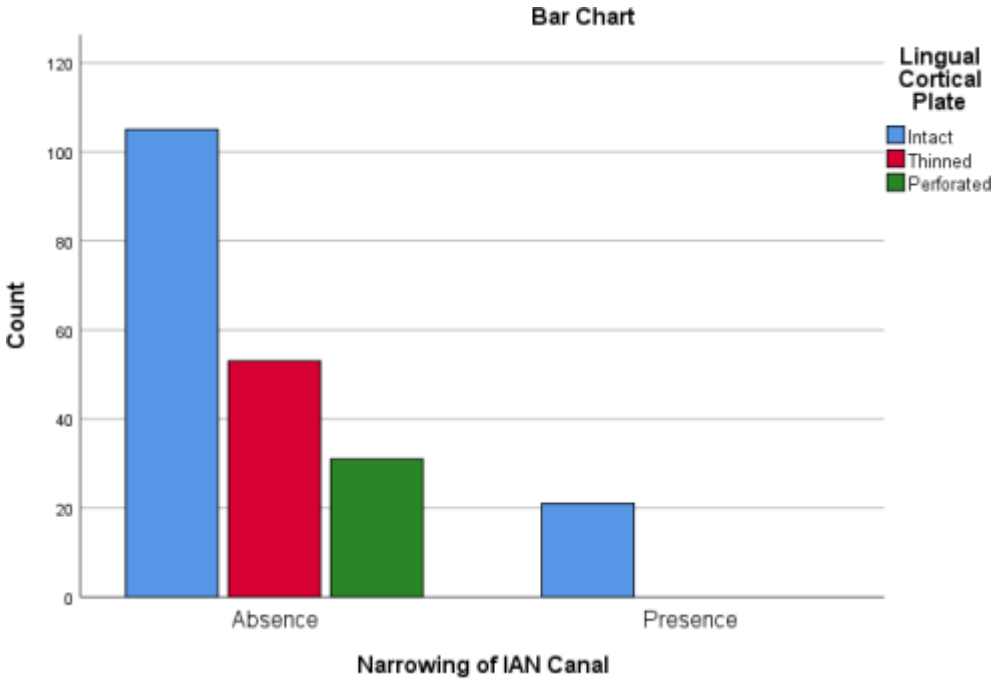
			IAN Position Relative		
			Buccal	Lingual	Interradicular
Darkening of Roots	Absence	Count	31	63	32
		% within Darkening of Roots	21.1%	42.9%	21.8%
	Presence	Count	63	0	0
		% within Darkening of Roots	100.0%	0.0%	0.0%
Total		Count	94	63	32
		% within Darkening of Roots	44.8%	30.0%	15.2%

Crosstab

			IAN Position Relative Inferior	Total
Darkening of Roots	Absence	Count	21	147
		% within Darkening of Roots	14.3%	100.0%
	Presence	Count	0	63
		% within Darkening of Roots	0.0%	100.0%
Total		Count	21	210
		% within Darkening of Roots	10.0%	100.0%

Fig6: Crosstabulation table showing the relation betwixt radiographic signs and the position of the IAN canal relative to the IMTM roots (buccal, lingual, interradicular, inferior) on CBCT.





The paired samples statistics show comparisons between PR and CBCT evaluations across three categories: Technical, Diagnostic, and Thinking. CBCT consistently had higher mean scores than PR, indicating better performance or perception. For Technical, CBCT scored 2.97 versus PR's 1.97; for Diagnostic, CBCT scored 2.83 versus PR's 2.49; and for Thinking, CBCT scored 2.70 versus PR's 2.28. Standard deviations and errors were smaller for CBCT, suggesting more consistent results compared to PR.

Paired Samples Statistics	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 PR Technical	1.97	210	0.530	0.037
CBCT Technical	2.97	210	0.167	0.012
Pair 2 PR Diagnostic	2.49	210	0.501	0.035
CBCT Diagnostic	2.83	210	0.374	0.026

Pair 3 PR Thinking	2.28	210	0.570	0.039
CBCT Thinking	2.70	210	0.457	0.032

DISCUSSION

This study evaluated the diagnostic efficacy of cone-beam computed tomography (CBCT) and panoramic radiography (PR) in assessing the relation betwixt impacted mandibular third molars (IMTMs) and the inferior alveolar nerve (IAN) canal using the Fryback and Thornbury hierarchical model. The findings demonstrated the superiority of CBCT over PR across all levels of diagnostic efficacy, including technical efficacy, diagnostic accuracy, and diagnostic thinking efficacy.

Technical Efficacy

CBCT provided significantly higher technical efficacy scores compared to PR, indicating superior image quality and visibility of anatomical structures. This advantage of CBCT can be attributed to its three-dimensional imaging capabilities and higher spatial resolution, which allow for better delineation of the IMTM roots, IAN canal, and their spatial relationships (Patel et al., 2020). Previous studies have also reported the superiority of CBCT over conventional two-dimensional imaging modalities in visualizing these critical anatomical structures (Suomalainen et al., 2010; Umar et al., 2012; Ghaeminia et al., 2015).

Diagnostic Accuracy

The diagnostic accuracy of CBCT was significantly higher than PR in identifying contact or loss of cortication between IMTM roots and the IAN canal. This finding is persistent with previous research demonstrating the increased accuracy of CBCT in detecting IMTM-IAN proximity and potential nerve injury risk (Patel et al., 2020; Neves et al., 2012; Jung et al., 2012; Tantanapornkul et al., 2009; Umar et al., 2012; Ghaeminia et al., 2015). The ability of CBCT to provide cross-sectional and three-dimensional views of the region of interest allows for a more precise assessment of the spatial relationships betwixt IMTM roots and the IAN canal.

Diagnostic Thinking Efficacy

CBCT scored significantly higher than PR in diagnostic thinking efficacy, suggesting that the improved visualization and accurate assessment of IMTM-IAN relationships provided by CBCT enhance diagnostic confidence and aid in treatment planning. This finding is particularly important, as accurate preoperative assessment of IMTM-IAN proximity is crucial for determining the appropriate surgical approach and minimizing the risk of iatrogenic nerve injury (Patel et al., 2020; Umar et al., 2012; Ghaeminia et al., 2015; Suomalainen et al., 2010).

Radiographic Signs and CBCT Findings

The study identified significant associations between specific radiographic signs on PR and CBCT findings related to cortication status, cortical plate integrity, and IAN canal position. Notably, the presence of darkening of roots, interruption of the white line, and narrowing of roots on PR were strongly associated with loss of cortication betwixt IMTM roots and the IAN canal on CBCT. These results are persistent with previous reports (Patel et al., 2020; Neves et al., 2012; Jung et al., 2012) and highlight the importance of carefully evaluating panoramic radiographs for these signs, which may indicate a raised risk of IAN injury during third molar removal.

Position of the IAN Canal and Cortical Plate Status

The study found that loss of cortication between IMTM roots and the IAN canal was most regularly noticed when the IAN canal was in an interradicular or buccal position relative to the IMTM roots. Additionally, thinning or perforation of the buccal and lingual cortical plates was significantly associated with specific panoramic signs, such as darkening of roots and interruption of the white line. These results underscore the importance of assessing not only the proximity of IMTM roots to the IAN canal but also the integrity of the surrounding cortical plates, as both factors can impact the potential of nerve injury during third molar extraction (Patel et al., 2020; Umar et al., 2012; Tantanapornkul et al., 2009; Ghaeminia et al., 2015).

Diagnostic Efficacy Hierarchy

The results of this study support the use of CBCT for the preoperative evaluation of IMTMs, particularly in cases where panoramic radiographs suggest a heightened risk of IAN injury. While CBCT involves higher radiation exposure and costs compared to PR, its superior diagnostic accuracy justifies its use in high-risk cases, as it can guide surgical decision-making and potentially prevent iatrogenic nerve injuries (Patel et al., 2020; Neves et al., 2012; Umar et al., 2012; Suomalainen et al., 2010; Monaco et al., 2004).

Limitations

This study has several limitations that should be acknowledged. First, it was a retrospective study, which may introduce selection bias. Second, the sample size was small, and the study was done at a single institution, potentially limiting the generalizability of the findings. Third, the study focused primarily on

the diagnostic efficacy of CBCT and PR, while therapeutic and societal efficacy levels were not thoroughly evaluated. Future prospective, multicenter studies with larger sample sizes and longer-term follow-up are assured to further investigate the impact of CBCT on treatment outcomes and patient-reported outcomes.

CONCLUSIONS

In conclusion, this study demonstrated the superiority of CBCT over panoramic radiograph in assessing the relationship between impacted mandibular third molars and the inferior alveolar nerve canal. CBCT provided higher technical efficacy, diagnostic accuracy, and diagnostic thinking efficacy compared to PR. The presence of specific radiographic characters on PR, such as darkening of roots, interruption of the white line, and narrowing of roots, was significantly linked with CBCT findings of loss of cortication, thinning or perforation of cortical plates, and increased proximity of the IAN canal to IMTM roots. These findings highlight the importance of careful preoperative evaluation and the potential benefits of CBCT in high-risk cases to guide surgical decision-making and decrease the risk of iatrogenic nerve truma.

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