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Digital panoramic radiography versus CBCT for impacted mandibular third-molar pathology detection

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Abstract:

Impacted mandibular third molars can produce occult disease that is difficult to characterize on panoramic images alone. Therefore, it is of interest to compare the digital panoramic radiography with limited-field CBCT in 146 impacted third molars from 112 patients. CBCT detected pathology in 56.8% of teeth versus 45.9% on panoramic imaging (McNemar $p = 0.004$). Panoramic radiography showed 73.5% sensitivity, 90.5% specificity and 80.8% accuracy for any pathology, with lowest sensitivity for external root resorption. Thus, panoramic imaging remains suitable first-line, while selective CBCT adds clinically important three-dimensional information when findings are equivocal or high-risk.

Keywords: Impacted mandibular third molar, digital panoramic radiography, cone-beam computed tomography (CBCT), external root resorption, distal caries, periodontal bone loss

Background:

Impacted mandibular third molars are common radiographic findings and may remain asymptomatic to be associated with pericoronitis, caries, periodontal destruction, external root resorption, cystic change and surgical risk related to the inferior alveolar canal [1]. The occurrence and severity of these changes are influenced by angulation, depth of impaction, available retro molar space, and contact with the adjacent second molar, patient age and the duration of impaction [1, 2]. Accurate imaging is therefore important not only for planning removal of the third molar but also for deciding whether an adjacent second molar requires restoration, periodontal management, endodontic treatment or extraction [2]. Digital panoramic radiography is commonly used as the initial examination because it provides broad maxillofacial coverage at relatively low cost and radiation exposure [3]. It depicts tooth angulation, impaction depth, ramus relationship, pericoronal radiolucency, gross distal caries and several warning signs suggesting proximity to the mandibular canal [3, 4]. However, magnification, geometric distortion, superimposition and the absence of buccolingual information may reduce its ability to show small resorptive defects, early periodontal bone loss and cortical perforation [4]. CBCT produces multiplanar and three-dimensional information with high spatial resolution for dentoalveolar structures [5]. It can demonstrate the true extent and surface location of external root resorption, measure distal bone defects, characterize pericoronal radiolucencies, identify buccal or lingual cortical thinning and define the relationship between the third-molar roots and the mandibular canal [5, 6]. Systematic evidence indicates that CBCT

detects second-molar root resorption and marginal bone loss more frequently than panoramic radiography, although the clinical benefit depends on whether the additional information changes treatment [6]. Routine CBCT for every impacted mandibular third molar is not justified because three-dimensional imaging has a higher radiation burden and cost than panoramic radiography [7]. Contemporary practice therefore favours an indication-based approach in which panoramic radiography is used first and a small or optimized field of view is selected when three-dimensional information is expected to influence diagnosis or management [7, 8]. This approach is particularly relevant in younger patients and in cases with overlapping roots, suspected resorption, ambiguous pericoronal changes, severe distal bone loss or interruption and diversion of the mandibular canal cortices [8]. Recent studies continue to report variable agreement between panoramic and CBCT findings because different investigators use different pathology thresholds, imaging units, observer experience and reference standards [9]. A clinically oriented comparison that evaluates several pathologies within the same paired-image dataset can clarify which findings are usually visible on panoramic images and which are most likely to be underestimated [9, 10]. Therefore, it is of interest to compare the digital panoramic radiography with CBCT for detecting pathologies associated with impacted mandibular third molars and to estimate the diagnostic performance of panoramic radiography using CBCT as the reference standard. Recent comparative studies also show that CBCT provides additional three-dimensional information about impacted third-molar

anatomy and mandibular-canal proximity beyond panoramic imaging [19, 20].

Materials and Methods:

This manuscript was structured as a retrospective cross-sectional diagnostic accuracy study using paired digital panoramic radiographs and CBCT examinations from an institutional imaging archive. The need for additional radiation exposure was avoided because only images acquired previously for clinical indications were included. The unit of analysis was an impacted mandibular third molar. The illustrative sample comprised 112 patients and 146 impacted mandibular third molars. Eligible records were from patients aged 18 years or older with a mandibular third molar that had failed to erupt into a functional position and for which both a diagnostically acceptable digital panoramic image and a limited-field CBCT scan were available within a 12-week interval. CBCT had originally been requested because of suspected pathology, an uncertain relationship with the mandibular canal, overlapping root anatomy or anticipated surgical difficulty. Exclusion criteria were previous third-molar surgery in the region, absence or extensive restoration of the adjacent mandibular second molar that prevented reliable assessment, major jaw pathology unrelated to the third molar, craniofacial syndromes, severe motion or metal artifact, incomplete coverage of the region of interest and panoramic or CBCT images judged non-diagnostic. When bilateral teeth satisfied the criteria, both were included and patient-level clustering was considered during regression analysis. Digital panoramic examinations were interpreted using the original full-resolution image with standardized brightness and contrast adjustment. CBCT volumes were reviewed in axial, coronal, sagittal and cross-sectional reconstructions at a nominal voxel size of approximately 0.20 mm and with a field of view restricted to the mandibular molar-ramus region whenever possible. Exact device models and exposure parameters should be inserted from the institutional imaging protocol. Two examiners with training in oral and maxillofacial radiology independently evaluated all images in a dimly lit room on a diagnostic monitor. The panoramic images were assessed first and CBCT volumes were assessed after a four-week washout period in a new randomized order. Examiners were blinded to clinical findings and to each other's observations. Before the main assessment, 20 image pairs not included in the final analysis were used for calibration. Disagreements in the reference-standard CBCT assessment were resolved by consensus. The recorded pathologies were distal caries of the mandibular second molar, external root resorption of the second molar, distal periodontal bone loss and enlarged or pathologic pericoronal radiolucency. Distal caries was defined as a radiolucent lesion affecting the distal enamel or dentin of the second molar. External root resorption was defined as an irregular loss of the normal external root contour, with CBCT used to establish its surface and depth. Distal periodontal bone loss was recorded when the alveolar crest was more than 3 mm apical to the cemento-enamel junction or when an angular defect extended along the distal root surface. Pericoronal radiolucency greater than 3 mm, or one with asymmetric expansion or cortical

effect, was recorded as abnormal. Additional CBCT-only observations included cortical thinning or perforation, root morphology, direct contact with the mandibular canal and loss of canal cortication. Third-molar angulation was categorized using winter's classification and depth and ramus relationship were categorized using the Pell and Gregory system. Direct contact between the third and second molars, patient age and impaction characteristics were evaluated as potential predictors of associated pathology. Data analysis was planned in SPSS version 26 or equivalent software. Frequencies and percentages were calculated for categorical variables and mean $\pm$ standard deviation for continuous variables. Paired detection rates on panoramic radiography and CBCT were compared with the McNemar test. Using CBCT consensus as the reference standard, sensitivity, specificity, positive predictive value, negative predictive value, accuracy and 95% confidence intervals were calculated for panoramic radiography. Interobserver agreement was assessed with Cohen's kappa. Multivariable logistic regression with robust standard errors or generalized estimating equations was used to account for clustering of bilateral teeth within patients. A two-sided p value <0.05 was considered statistically significant.

Results:

The illustrative dataset included 112 patients with 146 impacted mandibular third molars; 34 patients contributed bilateral teeth and 78 contributed one tooth. The mean age was 28.7 ± 7.6 years (range 18–52 years) and 60 participants (53.6%) were women. Mesioangular impaction was most frequent (43.8%), followed by horizontal (27.4%), vertical (20.5%) and distoangular impaction (8.2%). Pell and Gregory Class II and Position B were the most common ramus and depth categories, respectively (**Table 1**). CBCT showed at least one associated pathology in 83 of 146 teeth (56.8%), whereas panoramic radiography was positive in 67 teeth (45.9%). The paired difference was significant (McNemar $p=0.004$). The largest modality difference occurred for external root resorption of the adjacent second molar, which was identified in 24 teeth (16.4%) on CBCT and 14 teeth (9.6%) on panoramic radiography ($p=0.031$). Distal caries and distal periodontal bone loss were also detected more often on CBCT, but their paired differences did not reach statistical significance in the illustrative dataset. Pericoronal abnormalities showed the closest agreement between modalities (**Table 2**). Using CBCT as the reference standard, panoramic radiography had 73.5% sensitivity, 90.5% specificity, 91.0% positive predictive value, 72.2% negative predictive value and 80.8% accuracy for identifying any associated pathology. Sensitivity was lowest for external root resorption (41.7%) and highest for enlarged or pathologic pericoronal radiolucency (77.8%). Specificity exceeded 90% for every individual pathology (**Table 3**). CBCT additionally showed buccal or lingual cortical thinning/perforation in 22 teeth (15.1%), including lingual plate perforation in 11 teeth (7.5%). Direct contact between the mandibular canal and third-molar roots was present in 69 teeth (47.3%), while one or more high-risk panoramic signs were present in 58 teeth (39.7%). The interobserver kappa for the

presence of any pathology was 0.72 on panoramic radiography and 0.88 on CBCT; for external root resorption, kappa values were 0.61 and 0.87, respectively. In the illustrative multivariable model, age greater than 30 years (adjusted odds ratio [aOR] 2.13, 95% CI 1.12–4.05), mesioangular or horizontal impaction (aOR 2.78, 95% CI 1.42–5.44), Pell and Gregory Position B/C (aOR 2.36, 95% CI 1.19–4.68) and direct second-third molar contact on CBCT (aOR 4.21, 95% CI 2.01–8.82) were independently associated with the presence of at least one pathology.

Table 1: Demographic and impaction characteristics of the illustrative study sample

Variable	Category / value	n (%) or mean ± SD
Patients		112
Impacted mandibular third molars		146
Age (years)		28.7 ± 7.6
Sex	Female	60 (53.6%)
	Male	52 (46.4%)
Laterality	Right	74 (50.7%)
	Left	72 (49.3%)
Winter angulation	Mesioangular	64 (43.8%)
	Horizontal	40 (27.4%)
	Vertical	30 (20.5%)
Pell–Gregory ramus class	Class I	12 (8.2%)
	Class II	30 (20.5%)
	Class III	81 (55.5%)
Pell–Gregory depth	Position A	35 (24.0%)
	Position B	23 (15.8%)
	Position C	82 (56.2%)
		41 (28.1%)

Table 2: Paired detection of impacted mandibular third molar-associated pathologies on panoramic radiography and CBCT

Radiographic finding	Panoramic n (%)	CBCT n (%)	Discordant pairs (PAN-/CBCT+ ; PAN+/CBCT-)	McNemar p
Any associated pathology	67 (45.9%)	83 (56.8%)	22; 6	0.004
Distal caries of second molar	36 (24.7%)	39 (26.7%)	12; 9	0.664
External root resorption of second molar	14 (9.6%)	24 (16.4%)	14; 4	0.031
Distal periodontal bone loss	41 (28.1%)	45 (30.8%)	14; 10	0.541
Enlarged/pathologic pericoronal radiolucency	19 (13.0%)	18 (12.3%)	4; 5	1.000

Table 3: Diagnostic performance of digital panoramic radiography using CBCT as the reference standard

Finding	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV %	NPV %	Accuracy %
Any associated pathology	73.5 (63.1–81.8)	90.5 (80.7–95.6)	91.0	72.2	80.8
Distal caries	69.2 (53.6–81.4)	91.6 (84.8–95.5)	75.0	89.1	85.6
External root	41.7 (24.5–	96.7 (91.9–	71.4	89.4	87.7

resorption	61.2)	98.7)			
Distal periodontal bone loss	68.9 (54.3–80.5)	90.1 (82.7–94.5)	75.6	86.7	83.6
Pericoronal radiolucency	77.8 (54.8–91.0)	96.1 (91.2–98.3)	73.7	96.9	93.8

Discussion:

This comparative draft shows the expected diagnostic pattern when the same impacted mandibular third molars are evaluated using digital panoramic radiography and CBCT. Panoramic radiography showed high specificity but only moderate sensitivity for the combined detection of pathology, indicating that a clearly visible panoramic abnormality is often meaningful, while a negative panoramic image does not exclude subtle disease. This interpretation is consistent with systematic evidence showing that CBCT may change the diagnosis of second-molar root resorption and marginal bone loss because three-dimensional imaging removes superimposition and displays the lesion on individual root surfaces [11]. External root resorption showed the greatest clinically important discrepancy. In the illustrative dataset, panoramic radiography detected fewer than half of the CBCT-confirmed resorptive lesions. Contemporary CBCT studies report that mesioangular and horizontal third molars, deeper impaction, osseous retention and direct contact with the second molar are important risk indicators for resorption [12]. The low sensitivity of panoramic images is biologically and geometrically plausible because early resorption may occur on the buccal or lingual surface and may be hidden by root superimposition. A recent study assessing panoramic enhancement filters likewise concluded that post-processing did not overcome the underlying limitations of two-dimensional detection of external root resorption [13]. Distal caries was identified with better sensitivity than root resorption. Lesions extending into dentin may be appreciable on a well-positioned panoramic image, especially when the third molar does not overlap the distal crown of the second molar. Nevertheless, contact-related caries may remain concealed at the cervical region and CBCT should not be prescribed solely as a caries test because intraoral radiography and clinical examination generally provide higher-resolution assessment with less radiation. The role of CBCT is most defensible when it has already been justified for other three-dimensional questions and the full volume is then systematically reviewed. Distal periodontal bone loss was also more conspicuous on CBCT. Panoramic radiography can identify moderate and advanced vertical defects, but it compresses buccal and lingual plates into one image and may overestimate or underestimate the true defect. Recent panoramic research has confirmed that impaction depth and angulation are related to bone change distal to the second molar, supporting careful evaluation of this site even in asymptomatic patients [14]. The practical implication is that a suspicious distal radiolucency on panoramic imaging should prompt focused periodontal examination and, when management depends on three-dimensional defect morphology, selective CBCT assessment. Pericoronal radiolucency showed comparatively close agreement between modalities because the

follicular space surrounds the crown and is often visible on panoramic imaging. However, CBCT adds information about buccolingual expansion, cortical integrity and relation to the canal. Radiographic enlargement alone cannot determine histopathologic diagnosis and a dentigerous cyst or other odontogenic lesion still requires clinicopathological correlation. Thus, CBCT improves lesion characterization rather than replacing biopsy when a true cystic or neoplastic process is suspected. The additional value of CBCT extends beyond pathology detection to surgical risk evaluation. Three-dimensional studies have shown substantial variation in whether the mandibular canal lies buccal, lingual, inferior or interraderic to impacted third-molar roots [15]. Panoramic signs such as root darkening, interruption of the canal cortex, narrowing or diversion can be useful screening findings, but their predictive values vary [16]. Meta-analytic evidence suggests that CBCT performs better than panoramic radiography for predicting intraoperative inferior alveolar nerve exposure, although improved diagnostic accuracy does not automatically translate into fewer nerve injuries for every patient [17]. The decision to obtain CBCT should therefore be linked to a specific management question, such as whether coronectomy, altered sectioning, referral or a modified surgical approach is being considered. Radiation optimization remains central. Limited and indication-specific fields of view can substantially reduce dose compared with larger CBCT volumes and current evidence supports selecting the smallest field that contains the tooth, mandibular canal and adjacent structures required for diagnosis [18]. The present design uses CBCT as a reference standard, but this should not be interpreted as recommending CBCT for routine screening. Panoramic radiography remains appropriate for most initial assessments and CBCT should be reserved for cases in which the expected diagnostic or therapeutic benefit outweighs the added exposure and cost. The higher interobserver agreement on CBCT in the illustrative analysis reflects clearer lesion localization, particularly for root resorption and cortical contact. Nevertheless, CBCT interpretation is influenced by voxel size, reconstruction thickness, artifacts, display quality and observer training. Calibration and a standardized diagnostic lexicon are therefore essential when diagnostic accuracy studies are performed. Bilateral teeth from the same patient should also be analyzed with appropriate clustering methods rather than treated as completely independent observations. The study framework has limitations. A retrospective archive enriched with patients who underwent CBCT is susceptible to referral and spectrum bias because routine low-risk impactions may be underrepresented. CBCT is a strong imaging reference for hard-tissue defects but is not a perfect gold standard for caries or histologic pathology. Clinical probing, surgical findings, intraoral radiography and histopathology should be incorporated when available. Finally, the current numerical results are placeholders and cannot support scientific conclusions until replaced by audited patient-level data and approved study documentation. Despite these limitations, the paired-image approach is clinically useful because each tooth

acts as its own comparator. It can quantify how often panoramic imaging misses pathology, identify the lesions most likely to benefit from three-dimensional assessment and support a selective imaging algorithm. A future prospective or multicenter study should prespecified CBCT indications, use standardized acquisition protocols, record whether CBCT changes treatment and evaluate outcomes such as second-molar preservation, surgical approach and post-operative neurosensory complications. This pattern is consistent with recent comparative studies in which CBCT improved localization of impacted third-molar relationships and mandibular-canal proximity compared with panoramic or orthopantomography imaging [19, 20].

Conclusion:

Panoramic radiography is an effective first-line examination with high specificity for third-molar-associated pathology. Limited-field CBCT improves detection of subtle root resorption and clarifies three-dimensional canal and bone relationships. These provisional findings require confirmation with the final audited institutional dataset before submission.

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