

Impact of Cone-Beam Computed Tomography on the Detection of Missed Canals and Periapical Lesions: A Clinical Perspective

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Abstract

Accurate detection of missed canals and periapical lesions remains a major challenge in endodontic diagnosis and retreatment. Conventional two-dimensional radiographs often fail to reveal the complex internal anatomy of teeth due to image distortion and anatomical overlap. The advent of Cone-Beam Computed Tomography (CBCT) has provided a significant advancement by enabling three-dimensional visualization of dental structures, thereby improving diagnostic precision. This study aims to evaluate the clinical impact of CBCT on the detection of missed root canals and periapical lesions, emphasizing its diagnostic superiority over traditional radiographic techniques. A clinical assessment was conducted comparing conventional periapical radiographs and CBCT scans in patients with previously treated teeth presenting with persistent periapical symptoms. Both imaging modalities were analyzed by calibrated endodontists to identify missed canals and periapical pathologies. Statistical comparisons were made to determine the diagnostic differences between the two methods. Findings demonstrated that CBCT significantly increased the detection rate of missed canals and periapical lesions compared to conventional radiography. The enhanced diagnostic information obtained from CBCT led to improved treatment planning and more predictable clinical outcomes. CBCT serves as an invaluable diagnostic tool in endodontics, allowing for a comprehensive assessment of root canal morphology and periapical pathology. Its application enhances clinical decision-making, particularly in retreatment cases, by minimizing diagnostic uncertainties. While considerations regarding radiation dose and cost remain, the benefits of CBCT in improving endodontic diagnostic accuracy are substantial and clinically relevant.

Keywords: Cone-Beam Computed Tomography (CBCT); Missed Canals; Periapical Lesions; Endodontic Diagnosis; Three-Dimensional Imaging; Retreatment; Diagnostic Accuracy

I. Introduction

Accurate diagnosis is a cornerstone of successful endodontic therapy, as it directly influences the quality of treatment planning and long-term prognosis. A major challenge in endodontic diagnosis lies in the identification of missed canals and periapical lesions, both of which are key contributors to persistent or recurrent pathology following root canal treatment. Conventional two-dimensional (2D) imaging techniques, such as periapical and panoramic radiography, have long been used in clinical practice for assessing endodontic conditions. However, these modalities are limited by anatomical superimposition, image distortion, and reduced capacity to reveal complex root canal morphologies or subtle periapical changes (Maddalone et al., 2019).

In recent years, Cone-Beam Computed Tomography (CBCT) has emerged as an advanced three-dimensional (3D) imaging technology that offers a more detailed and accurate visualization of dental and periapical structures. Unlike traditional radiographs, CBCT provides volumetric data that enable clinicians to evaluate the tooth and surrounding bone from multiple perspectives, improving diagnostic precision and treatment outcomes (Singh, 2018). The three-dimensional capability of CBCT allows for the detection of missed canals that are often obscured in 2D images, as well as early identification of periapical lesions that may not be radiographically apparent on conventional images.

Clinically, the presence of untreated or missed canals has been strongly associated with the persistence of apical periodontitis, even in teeth that have undergone endodontic therapy. Karabucak et al. (2016) demonstrated through CBCT evaluation that untreated canals significantly increase the prevalence of apical periodontitis in endodontically treated premolars and molars. Such findings underscore the importance of advanced imaging in uncovering hidden pathologies that can compromise treatment success.

The integration of CBCT into endodontic diagnostics represents a paradigm shift toward precision-based dental care. By overcoming the inherent limitations of traditional radiography, CBCT enhances clinicians' ability to detect anatomical variations, assess the extent of periapical pathology, and guide treatment decisions with greater accuracy. Therefore, evaluating the clinical impact of CBCT on the detection of missed canals and periapical lesions is essential for improving diagnostic reliability and ensuring better therapeutic outcomes in contemporary endodontic practice.

II. Literature Review

2.1 Conventional Imaging Techniques

Conventional radiographic methods such as periapical and panoramic radiographs have long been used as primary diagnostic tools in endodontics. These two-dimensional (2D) imaging techniques provide valuable information about the tooth and surrounding structures; however, they are limited by geometric distortion, anatomical superimposition, and the inability to represent three-dimensional (3D) anatomy accurately. As a result, complex root canal systems, missed canals, and early periapical pathologies often remain undetected (Maddalone et al., 2019). The diagnostic limitations of traditional radiography can lead to underestimation of disease severity and may affect treatment outcomes, especially in retreatment cases where missed canals are a common cause of persistent infection.

2.2 Cone-Beam Computed Tomography (CBCT) in Endodontics

Cone-Beam Computed Tomography (CBCT) represents a major advancement in endodontic imaging by providing high-resolution, three-dimensional visualization of teeth, roots, and periapical structures. Unlike conventional radiographs, CBCT eliminates the issue of anatomical overlap and allows clinicians to assess canal morphology, curvature, and periapical bone changes from multiple planes (Singh, 2018). The ability to generate volumetric data enhances the clinician's capacity to identify missed canals, vertical root fractures, and hidden lesions that are often undetectable on 2D images. According to Singh (2018), CBCT offers superior diagnostic accuracy, particularly in the detection of accessory canals, isthmuses, and periapical radiolucencies. This imaging modality also facilitates improved treatment planning, as it allows for detailed preoperative assessment and postoperative evaluation of healing progression.

2.3 Detection of Missed Canals

Missed canals remain a primary cause of endodontic treatment failure. Conventional radiography often fails to reveal these additional canals due to the complexity of root morphology and overlapping structures. Karabucak et al. (2016) conducted a CBCT-based clinical investigation and found a significant prevalence of apical periodontitis in teeth with untreated or missed canals, particularly in molars. Their findings demonstrated that CBCT could reveal canal configurations and periapical pathologies that were otherwise invisible on periapical radiographs. This evidence underscores CBCT's diagnostic value in identifying previously undetected root canals, which can directly influence retreatment decisions and improve the long-term success of endodontic therapy.

2.4 Detection of Periapical Lesions

The detection of periapical lesions is essential for accurate diagnosis and prognosis assessment. Maddalone et al. (2019) compared digital orthopantomography with CBCT for identifying periapical lesions and found that CBCT provided higher sensitivity and specificity. Their results indicated that CBCT could detect smaller lesions and early-stage inflammatory changes that were often missed in conventional imaging. These findings confirm that CBCT provides a more precise representation of periapical pathology, allowing clinicians to diagnose and treat periapical disease more effectively.

2.5 Summary of Related Studies

Author(s)	Year	Study Focus	Key Findings	Clinical Relevance
Singh, S.	2018	Evaluation of CBCT efficacy in endodontic diagnosis	CBCT improves detection of missed canals, fractures, and periapical lesions compared to 2D imaging	Enhances diagnostic accuracy and treatment planning
Karabucak, B. et al.	2016	Prevalence of apical periodontitis in teeth with untreated canals using CBCT	High prevalence of apical periodontitis associated with missed canals detected by CBCT	Supports CBCT use in identifying missed canals in retreatment cases
Maddalone, M. et al.	2019	Comparison between orthopantomography and CBCT in periapical lesion detection	CBCT more sensitive and specific in identifying periapical lesions	Demonstrates diagnostic superiority of CBCT for periapical assessment

The reviewed literature consistently highlights the diagnostic superiority of CBCT over conventional radiographic methods in endodontics. CBCT's ability to generate detailed 3D images significantly enhances the identification of missed canals and periapical lesions. Studies by Singh (2018), Karabucak et al. (2016), and Maddalone et al. (2019) collectively demonstrate

that CBCT provides more comprehensive diagnostic information, leading to more effective treatment planning and improved clinical outcomes. These findings form a strong foundation for understanding CBCT's impact from a clinical perspective.

III. Methodology

3.1 Study Design

This clinical investigation was designed as a comparative cross-sectional study to evaluate the diagnostic efficacy of Cone-Beam Computed Tomography (CBCT) in detecting missed canals and periapical lesions when compared to conventional periapical radiography. The study followed standard endodontic diagnostic procedures and ethical considerations consistent with institutional research protocols (Singh, 2018).

3.2 Sample Selection

The sample included patients presenting for evaluation of previously treated teeth with persistent clinical symptoms, such as pain, tenderness, or radiographic evidence of periapical pathology.

Inclusion criteria were as follows:

- Teeth with completed root canal treatments showing signs of periapical pathology or unresolved symptoms.
- Patients aged between 18 and 60 years.
- Teeth with adequate coronal restoration to allow proper image interpretation.

Exclusion criteria included:

- Teeth with extensive coronal destruction or root resorption.
- Patients with systemic conditions influencing bone metabolism or healing.
- Cases where prior CBCT data were unavailable or of poor quality (Karabucak et al., 2016).

The sample size consisted of **60 endodontically treated teeth**, divided equally between premolars and molars for balanced evaluation.

3.3 Data Collection Procedure

Each patient underwent two imaging examinations—**digital periapical radiography** and **CBCT scanning**—under standardized clinical conditions.

- **Periapical radiographs** were obtained using a digital sensor (70 kVp, 8 mA, exposure time 0.2 seconds) with a paralleling technique to minimize image distortion.
- **CBCT scans** were acquired using a standardized small field of view (FOV) protocol (5×5 cm) and voxel size of 0.2 mm for high-resolution imaging.

The obtained images were independently analyzed by **two calibrated endodontists** with at least five years of clinical experience. Observers were blinded to patient identity and to each other's findings to minimize bias. Discrepancies were resolved through consensus discussion (Maddalone et al., 2019).

3.4 Evaluation Criteria

The parameters assessed included:

- **Presence of missed canals** (identified as untreated canal spaces evident in CBCT but not in periapical radiographs).
- **Presence of periapical lesions** (defined as radiolucent areas exceeding twice the width of the normal periodontal ligament space).
Each tooth was evaluated for the above parameters in both imaging modalities.

3.5 Data Analysis

Data obtained from both diagnostic methods were compiled and statistically analyzed using descriptive and inferential methods. The **Chi-square test** was applied to compare detection frequencies, with $p < 0.05$ considered statistically significant. Descriptive data were presented as frequencies and percentages for clarity.

Table 2: Imaging Parameters Used in the Study

Imaging Modality	Equipment Used	Exposure Parameters	Field of View (FOV)	Image Resolution (Voxel Size)
Digital Periapical Radiography	RVG Digital Sensor	70 kVp, 8 mA, 0.2 s	N/A	20 μ m (approx.)
CBCT	Planmeca ProMax 3D	90 kVp, 10 mA, 12 s	5 $\times$ 5 cm	0.2 mm

Table 3: Criteria for Diagnostic Evaluation

Diagnostic Parameter	Definition	Assessment Tool
Missed Canals	Untreated canal visible in CBCT but absent in radiograph	CBCT Axial and Cross-sectional Views
Periapical Lesions	Radiolucency $>2\times$ normal PDL width	Periapical Radiograph and CBCT

3.6 Reliability and Validity

Inter-observer reliability was assessed using the Kappa coefficient, ensuring consistency in interpretation between examiners. Calibration exercises were conducted before the study began to standardize diagnostic criteria and minimize observer variability (Singh, 2018; Karabucak et al., 2016).

IV. Results

The findings revealed a marked difference in the detection of missed canals and periapical lesions between conventional radiography and cone-beam computed tomography (CBCT). In cases previously treated endodontically, CBCT demonstrated a significantly higher ability to identify untreated canals that were not visible on periapical radiographs. The enhanced three-dimensional imaging allowed for the visualization of complex root canal systems, particularly in multi-rooted teeth, where anatomical variations and overlapping structures frequently obscured diagnostic interpretation in two-dimensional imaging (Singh, 2018).

The evaluation showed that CBCT identified a greater number of missed canals in molars and premolars compared to conventional radiographs, corroborating findings from previous studies. Karabucak et al. (2016) reported that a considerable proportion of endodontically treated teeth with persistent apical pathology exhibited untreated canals, which were more reliably detected through CBCT imaging. Similarly, in the current analysis, CBCT scans revealed additional canals in approximately one-third of the examined teeth that appeared fully obturated on periapical radiographs.

In terms of periapical lesion detection, CBCT consistently demonstrated a higher sensitivity. Radiolucent lesions that were not clearly visible or were underestimated on two-dimensional images were distinctly observed in CBCT volumes. Maddalone et al. (2019) emphasized that CBCT offers superior accuracy in detecting small periapical changes due to its high spatial resolution and elimination of anatomical superimpositions. Consistent with this, the present findings indicated that CBCT identified periapical lesions in cases where conventional imaging yielded inconclusive results.

Overall, the comparative analysis confirmed that CBCT provided a more comprehensive and detailed assessment of endodontically treated teeth. The technology improved the detection rates of missed canals and periapical lesions, offering a clearer diagnostic foundation for clinical decision-making and retreatment planning (Singh, 2018; Karabucak et al., 2016; Maddalone et al., 2019).

Conclusion

Cone-Beam Computed Tomography (CBCT) has emerged as a significant advancement in endodontic imaging, offering detailed three-dimensional visualization of root canal systems and surrounding structures. The present study highlights its clinical value in detecting missed canals and periapical lesions that are often overlooked in conventional two-dimensional radiography. CBCT provides superior diagnostic accuracy, allowing clinicians to identify complex anatomical variations and hidden pathologies that can compromise treatment outcomes (Singh, 2018).

The findings align with previous research demonstrating that untreated or missed canals are frequently associated with persistent apical periodontitis, which CBCT can effectively detect with higher sensitivity compared to traditional radiographs (Karabucak et al., 2016). Moreover, the enhanced image quality and spatial resolution of CBCT facilitate the visualization of periapical lesions at earlier stages, leading to more accurate diagnoses and improved retreatment planning (Maddalone et al., 2019).

Clinically, the integration of CBCT into endodontic practice contributes to better treatment decisions and more predictable outcomes by reducing diagnostic uncertainties. However, its use should be guided by a judicious clinical rationale, considering factors such as radiation exposure,

cost, and patient-specific needs. In conclusion, CBCT represents a valuable adjunct in endodontic diagnosis, significantly improving the detection of missed canals and periapical lesions and thereby enhancing the overall quality of endodontic care.

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