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Review Article

Diagnostic Accuracy of Cone-Beam Computed Tomography in Detecting Periapical Lesions; A Systematic Review

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Abstract

Background: Accurate detection of periapical lesions is essential for the diagnosis, treatment planning, and prognosis of endodontic diseases. Conventional radiographic techniques, including periapical and panoramic radiography, are widely used in clinical practice but are limited by their two-dimensional nature, anatomical superimposition, and geometric distortion. Cone-beam computed tomography (CBCT) has emerged as an advanced three-dimensional imaging modality that may improve the detection and characterization of periapical pathology. This systematic review aimed to evaluate the diagnostic accuracy of CBCT for detecting periapical lesions compared with conventional radiographic techniques. ***Methods:*** A systematic literature search was conducted in PubMed/MEDLINE, Scopus, ScienceDirect, Cochrane Library, and Google Scholar from database inception to May 2026. Studies evaluating the diagnostic performance of CBCT for detecting periapical lesions or apical periodontitis were considered eligible. Human clinical studies, cadaveric investigations, animal studies, and ex vivo studies were included. Data regarding study characteristics, reference standards, comparator imaging modalities, and diagnostic outcomes were extracted. Methodological quality was assessed using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool. Due to heterogeneity in study designs, reference standards, and outcome measures, a qualitative synthesis was performed. ***Results:*** The search identified 2,996 records, of which nine studies met the eligibility criteria and were included in the final qualitative synthesis. The included studies comprised clinical, histopathological, cadaveric, and experimental investigations. Across all studies, CBCT consistently demonstrated superior diagnostic performance compared with conventional radiographic techniques. Studies using histopathological and surgical reference standards reported higher sensitivity and overall diagnostic accuracy for CBCT in detecting periapical lesions. CBCT was particularly effective in identifying small lesions, lesions confined to cancellous bone, and lesions located in anatomically complex regions. Experimental studies also demonstrated greater lesion detection rates and diagnostic confidence with CBCT compared with periapical radiography. Overall, the evidence indicated that CBCT provides more accurate visualization and characterization of periapical pathology than conventional two-dimensional imaging methods. ***Conclusion:*** CBCT demonstrates superior diagnostic accuracy compared with conventional radiographic techniques for the detection of periapical lesions. Its three-dimensional imaging capability enhances the identification of early and complex lesions that may be missed on conventional radiographs. While CBCT should be used judiciously because of radiation exposure considerations, it represents a valuable diagnostic adjunct in cases where conventional imaging is inconclusive or additional diagnostic information is required.

Keywords: Cone-beam computed tomography; CBCT; Periapical lesions; Apical periodontitis; Diagnostic accuracy; Endodontics; Systematic review.

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INTRODUCTION

Apical periodontitis (AP) is a chronic inflammatory condition of periapical tissues that develops as a consequence of microbial infection within the root canal system. It is characterized by inflammatory destruction of the surrounding periapical bone and represents one of the most common pathological conditions encountered in endodontic practice. AP has substantial clinical significance because it may compromise treatment outcomes, contribute to persistent infection, and ultimately result in tooth loss if left untreated. Recent epidemiological evidence has demonstrated that AP constitutes a major global oral health burden, with a prevalence of approximately 52% at the individual level and 5% at the tooth level worldwide [1]. Furthermore, the prevalence of AP is considerably higher in root-filled teeth than in untreated teeth, emphasizing the importance of accurate diagnosis and long-term monitoring of endodontic conditions [1,2].

Radiographic examination plays a fundamental role in the diagnosis, treatment planning, and follow-up of apical periodontitis. Conventional imaging modalities, particularly periapical radiography, remain the most widely used diagnostic tools in endodontics because of their accessibility, low cost, and relatively low radiation dose [3]. However, conventional radiographs provide only a two-dimensional representation of three-dimensional anatomical structures and are therefore subject to several inherent limitations. Anatomical superimposition, geometric distortion, image compression, and the inability to accurately visualize lesions confined within cancellous bone may result in underestimation or non-detection of periapical pathology [4,5]. Consequently, a substantial number of lesions may remain undiagnosed until extensive cortical bone involvement occurs.

The introduction of cone-beam computed tomography (CBCT) has significantly advanced diagnostic imaging in endodontics. Unlike conventional radiography, CBCT provides three-dimensional visualization of dental and maxillofacial structures with minimal distortion and without the superimposition of adjacent anatomical structures [3,6]. This technology allows clinicians to evaluate the presence, extent, and anatomical relationships of periapical lesions more accurately than traditional two-dimensional imaging methods. Numerous investigations have reported that CBCT demonstrates greater sensitivity for detecting apical periodontitis, particularly in small lesions, lesions confined to cancellous bone, and lesions located in anatomically complex regions such as molars and multi-rooted teeth [7].

Evidence from experimental, cadaveric, and clinical studies has consistently suggested that CBCT outperforms conventional radiography in the detection and characterization of periapical pathology. Histopathological validation studies have shown significantly higher diagnostic accuracy for CBCT compared with periapical radiography [8], while systematic reviews have reported excellent overall diagnostic performance of CBCT for distinguishing teeth with and without apical periodontitis [7]. Moreover, lesions detected exclusively by CBCT have been shown to alter endodontic diagnosis and influence subsequent treatment decisions, highlighting the potential clinical impact of advanced three-dimensional imaging.

Despite these advantages, routine use of CBCT remains controversial because of concerns regarding increased radiation exposure, cost, and the need for appropriate case selection. Consequently, professional organizations such as the European Society of Endodontology recommend the selective use of CBCT in situations where conventional radiographic examinations are inconclusive or when additional diagnostic information is required for treatment planning [9].

Although numerous studies have evaluated the diagnostic performance of CBCT for the detection of periapical lesions, the available evidence is dispersed across different study designs, populations, reference standards, and imaging protocols. Therefore, a comprehensive synthesis of the current literature is warranted. The aim of this systematic review was to evaluate and summarize the available evidence regarding the diagnostic accuracy of cone-beam computed tomography for the detection of periapical lesions and apical periodontitis compared with conventional radiographic techniques and established reference standards.

MATERIALS AND METHODS

Protocol and Reporting Guidelines

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines [10]. The review was designed to evaluate the diagnostic accuracy of CBCT for the detection of periapical lesions and apical periodontitis compared with conventional radiographic techniques and other reference standards reported in the literature.

Eligibility Criteria

Studies were considered eligible if they evaluated the diagnostic performance of CBCT for the detection of periapical lesions or apical periodontitis and reported diagnostic outcomes such as sensitivity, specificity, accuracy, predictive values, receiver operating characteristic (ROC) analysis, area under the curve (AUC), or lesion detection rates. Human clinical studies, prospective and retrospective investigations, cadaveric studies, animal studies, and ex vivo studies were included. Studies comparing CBCT with conventional radiographic modalities, including periapical radiography, digital periapical radiography, panoramic radiography, orthopantomography, and

conventional radiography, were considered for inclusion. Only articles published in English were included.

Studies were excluded if they were review articles, systematic reviews, meta-analyses, editorials, letters, conference abstracts, or case reports. Studies primarily evaluating artificial intelligence systems without assessing the diagnostic performance of CBCT itself were excluded. Investigations focused on pathologies other than periapical lesions or apical periodontitis, such as root fractures, external root resorption, implant assessment, or non-endodontic lesions, were also excluded. Studies lacking sufficient diagnostic outcome data and non-English publications were not considered.

Information Sources and Search Strategy

A comprehensive electronic search was performed in PubMed/MEDLINE, Scopus, ScienceDirect, Cochrane Library, and Google Scholar from database inception until May 2026. Additional relevant studies were identified through manual screening of the reference lists of included articles and related reviews.

The search strategy incorporated a combination of Medical Subject Headings (MeSH) terms and free-text keywords related to CBCT and periapical lesions. The search terms included "cone-beam computed tomography," "CBCT," "apical periodontitis," "periapical lesion," "periapical radiolucency," "diagnostic accuracy," "sensitivity," and "specificity." The search strategy was adapted appropriately for each database.

Study Selection

All records identified through the electronic search were imported into reference management software, and duplicate records were removed. Two reviewers independently screened the titles and abstracts of all retrieved studies. Full texts of potentially eligible articles were then assessed against the predefined inclusion and exclusion criteria. Any disagreements regarding study eligibility were resolved through discussion and consensus. The entire study selection process was documented using a PRISMA flow diagram.

Data Extraction

Data extraction was performed independently by two reviewers using a standardized data extraction form. Information collected from each study included the first author, publication year, country, study design, sample size, study population, reference standard, comparator imaging modality, CBCT imaging parameters when available, and reported diagnostic outcomes. Diagnostic outcomes extracted included sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, ROC analysis, AUC values, and principal findings relevant to the diagnostic performance of CBCT. Any discrepancies identified during data extraction were resolved through discussion and consensus.

Quality Assessment

The methodological quality of the included studies was evaluated using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) tool. Risk of bias was assessed across four domains: patient selection, index test, reference standard, and flow and timing. Each domain was categorized as having low, high, or unclear risk of bias. Applicability concerns were also assessed according to the QUADAS-2 guidance document.

Data Synthesis

A quantitative meta-analysis was not performed because of substantial heterogeneity among the included studies with respect to study design, populations, lesion simulation methods, reference standards, CBCT imaging protocols, comparator modalities, and reported diagnostic outcomes. Therefore, a qualitative narrative synthesis was undertaken. The findings of the included studies were summarized and compared according to study characteristics, methodological quality, diagnostic performance measures, and reported advantages of CBCT over conventional radiographic techniques. Diagnostic outcomes such as sensitivity, specificity, predictive values, accuracy, and AUC values were synthesized descriptively to provide a comprehensive overview of the current evidence regarding the diagnostic accuracy of CBCT for detecting periapical lesions.

Quality Assessment

The methodological quality assessment of included studies using the QUADAS-2 tool is summarized in Table 1.

Table 1: Quality Assessment Using QUADAS-2

Study	Patient Selection	Index Test	Reference Standard	Flow & Timing	Overall Risk of Bias
Estrela *et al.,* (2008) [11]	Low	Low	High	Low	Moderate
Paula-Silva *et al.,* (2009) [12]	Low	Low	Low	Low	Low
Tsai *et al.,* (2012) [13]	High	Low	Low	Low	Moderate
Kanagasingam *et al.,* (2016) [8]	Low	Low	Low	Low	Low
Fagundes Campello *et al.,* (2017) [14]	High	Low	Low	Low	Moderate
Maddalone *et al.,* (2019) [15]	Low	Low	High	Low	Moderate
Keerthana *et al.,* [16]	Low	Low	Low	Low	Low

Study	Patient Selection	Index Test	Reference Standard	Flow & Timing	Overall Risk of Bias
Sheikhi *et al.,* (2024) [17]	High	Low	Low	Low	Moderate
Kanneppady *et al.,* (2025) [18]	Unclear	Low	Unclear	Unclear	Unclear

Overall, the risk of bias was considered low to moderate across most studies.

The studies by Paula-Silva et al. [12], Kanagasingam et al. [8], and Keerthana et al. [16] demonstrated the highest methodological quality due to the use of independent reference standards and clearly defined diagnostic protocols. Several ex vivo investigations, including those by Tsai et al. [13], Fagundes Campello et al. [14], and Sheikhi et al. [17], exhibited a moderate risk of bias related to patient selection domains because of their experimental designs. Studies that used CBCT as the reference method for comparison with conventional radiography were judged to have higher concerns regarding the reference standard domain. Nevertheless, all included studies provided valuable evidence regarding the diagnostic capabilities of CBCT for detecting periapical lesions.

RESULTS

Study Selection

The literature search identified a total of 2,996 records from electronic databases, including PubMed (n = 882), Scopus (n = 311), ScienceDirect (n = 1,448), Cochrane Library (n = 17), and Google Scholar (n = 338). Following the removal of 263 duplicate records and 166 records removed for other reasons, 2,567 studies remained for title and abstract screening. Of these, 2,454 records were excluded based on the predefined eligibility criteria. A total of 113 reports were sought for retrieval, of which 29 could not be obtained. Consequently, 84 full-text articles were assessed for eligibility. After full-text review, 75 studies were excluded, including 14 studies that were not original investigations and 61 studies that did not evaluate the diagnostic performance of cone-beam computed tomography (CBCT) for the detection of periapical lesions. Ultimately, nine studies met the inclusion criteria and were included in the qualitative synthesis. The study selection process is presented in Figure 1.

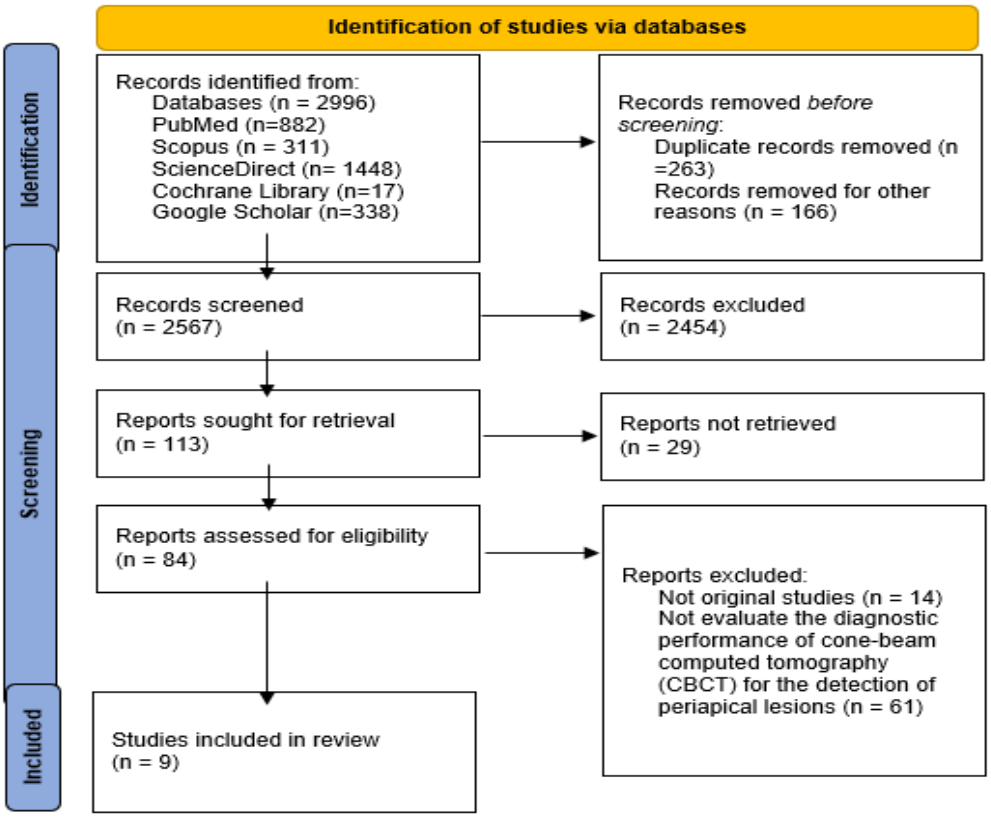


Figure 1: PRISMA flowchart showing the study selection process.

Characteristics of Included Studies

The characteristics of the included studies are summarized in Table 1. The nine studies [8,11–18]were published between 2008 and 2025 and comprised a variety of study designs, including clinical observational studies, prospective clinical investigations, cadaveric studies, animal studies, and ex vivo experimental models. Collectively, the studies evaluated the diagnostic

performance of cone-beam computed tomography (CBCT) for the detection of periapical lesions or apical periodontitis and compared its performance with conventional imaging modalities such as periapical radiography (PR), digital periapical radiography (DPR), panoramic radiography, orthopantomography (OPT), or conventional radiography.

Three studies used independent gold standards for validation, including histopathological examination and direct surgical visualization. Paula-Silva et al. [12] utilized histopathological findings in a canine model, Kanagasingam et al. [8] employed human cadaver histopathology, and Keerthana et al. [16] used direct surgical visualization as the reference standard. Other studies compared CBCT with conventional radiographic techniques in either clinical or experimental settings. The sample sizes varied considerably, ranging from 11 teeth in an ex vivo model to 1,508 teeth in a large clinical imaging study (Table 2).

Table 2: Characteristics of Included Studies

Author (Year)	Country	Study Design	Sample/Unit of Analysis	Reference Standard	Comparator	Main Objective
Estrela *et al.,* (2008) [11]	Brazil	Clinical observational study	888 imaging examinations; 1508 teeth	CBCT used as reference method	Periapical and panoramic radiography	To compare accuracy of imaging methods for detection of apical periodontitis
Paula-Silva *et al.,* (2009) [12]	Brazil/Netherlands	Experimental animal study	83 roots	Histopathology	Periapical radiography	To evaluate diagnostic accuracy of CBCT and PR for apical periodontitis
Tsai *et al.,* (2012) [13]	USA	Ex vivo cadaver study	16 roots	Artificially created lesions	Periapical radiography	To assess accuracy of CBCT for detection of small periapical lesions
Kanagasingam *et al.,* (2016) [8]	Malaysia/UK	Cadaveric diagnostic accuracy study	67 teeth (86 roots)	Histopathology	Periapical radiography	To compare diagnostic accuracy of CBCT and PR in detecting AP
Fagundes Campello *et al.,* (2017) [14]	Brazil	Ex vivo study	11 teeth	Artificially created lesions	Digital periapical radiography	To compare diagnostic accuracy of CBCT and DPR
Maddalone *et al.,* (2019) [15]	Italy	Clinical cohort study	45 patients	CBCT used as reference method	Orthopantomography (OPT)	To evaluate effectiveness of OPT versus CBCT for periapical lesion detection
Keerthana *et al.,* [16]	India	Prospective clinical study	74 patients; 112 teeth	Direct surgical visualization	Periapical radiography	To compare diagnostic accuracy of CBCT and PR in complex endodontic pathoses
Sheikhi *et al.,* (2024) [17]	Iran	Ex vivo study	67 sockets	Artificial defects (gold standard dimensions)	Periapical radiography	To compare CBCT FOVs and PR for lesion detection
Kanneppady *et al.,* (2025) [18]	India	Comparative clinical study	Dental patients	Clinical/radiographic assessment	Conventional radiography	To compare CBCT and conventional radiography for detecting periapical lesions

Diagnostic Accuracy of CBCT for Detecting Periapical Lesions

The diagnostic performance outcomes reported by the included studies are summarized in Table 3.

Table 3: Diagnostic Accuracy Outcomes of Included Studies

Study	Sensitivity (CBCT)	Specificity (CBCT)	Accuracy/AUC	Major Findings
Estrela *et al.,* (2008) [11]	Not reported	Not reported	CBCT identified significantly more AP lesions	CBCT superior to conventional radiography
Paula-Silva *et al.,* (2009) [12]	0.91	1	0.92	CBCT significantly more accurate than PR
Tsai et al. (2012) [13]	Variable according to lesion size	Variable	AUC 0.753–0.767	CBCT superior for lesions >0.8 mm
Kanagasingam *et al.,* (2016) [8]	0.89	1	AUC 0.943	Highest diagnostic performance among modalities
Fagundes Campello *et al.,* (2017) [14]	Higher than DPR	Not reported	56.9–73.6% correct diagnosis	CBCT significantly more accurate
Maddalone *et al.,* (2019) [15]	Reference method	Reference method	Not applicable	CBCT detected substantially more lesions
Keerthana *et al.,* [16]	91–96% overall accuracy	High	91–96%	CBCT superior in complex endodontic pathoses
Sheikhi *et al.,* (2024) [17]	96% (Dental FOV)	High	97.1% agreement	Dental FOV CBCT most accurate
Kanneppady *et al.,* (2025) [18]	Higher than CR	Higher than CR	Significant difference ($p<0.05$)	CBCT outperformed conventional radiography

Across all studies, CBCT consistently demonstrated superior diagnostic performance compared with conventional radiographic techniques.

Among studies using independent reference standards, Paula-Silva et al. [12] reported a sensitivity of 0.91 and an overall diagnostic accuracy of 0.92 for CBCT, compared with a sensitivity of 0.77 and an accuracy of 0.78 for periapical radiography. Similarly, Kanagasingam et al. [8] demonstrated a sensitivity of 0.89 and an area under the receiver operating characteristic curve (AUC) of 0.943 for CBCT, substantially exceeding the diagnostic performance of conventional radiographic approaches. In the prospective clinical study by Keerthana et al. [16], CBCT achieved overall diagnostic accuracies ranging from 91% to 96% for the assessment of complex endodontic pathoses, outperforming periapical radiography in the detection of periapical lesions, root perforations, apicomarginal defects, and through-and-through bone defects.

Clinical comparative studies further supported the superiority of CBCT. Estrela et al. [11] reported a significantly greater prevalence of apical periodontitis detected by CBCT compared with periapical and panoramic radiography, suggesting that conventional radiographs may underestimate the true extent of periapical disease. Likewise, Maddalone et al. [15] demonstrated that orthopantomography exhibited low sensitivity for lesion detection when compared with CBCT, particularly in posterior regions where anatomical superimposition may obscure pathology. Kanneppady et al. [18] also reported significantly higher sensitivity, specificity, and diagnostic accuracy for CBCT than conventional radiography.

Experimental studies yielded similar findings. Tsai et al. [13] demonstrated that CBCT was significantly more accurate than periapical radiography for detecting simulated periapical lesions, particularly when lesion diameters exceeded 0.8 mm. Fagundes Campello et al. [14] observed significantly higher diagnostic accuracy for CBCT in identifying artificially created periapical lesions across all lesion sizes tested. Similarly, Sheikhi et al. [17] reported that CBCT, particularly when using a limited dental field of view, achieved the highest sensitivity (96%) and diagnostic agreement with the gold standard, substantially outperforming conventional periapical radiography.

Diagnostic Advantages of CBCT

The major diagnostic advantages of CBCT identified across the included studies are presented in Table 4.

Table 4: Summary of Advantages of CBCT Identified Across Studies

Diagnostic Feature	Evidence from Included Studies
Detection of early lesions	Demonstrated by Tsai, Kanagasingam, Paula-Silva
Detection of lesions hidden within cancellous bone	Demonstrated by Estrela, Kanagasingam, Paula-Silva
Higher sensitivity than periapical radiography	Reported in most included studies

Diagnostic Feature	Evidence from Included Studies
Better visualization of lesion size and extent	Reported by Sheikhi, Tsai, Fagundes Campello
Improved assessment of complex anatomy	Reported by Keerthana
Reduced superimposition of anatomical structures	Reported consistently across studies
Superior diagnostic confidence	Reported in clinical and experimental studies

CBCT consistently demonstrated superior sensitivity for detecting early-stage periapical lesions and lesions confined within cancellous bone, which are frequently missed on conventional radiographs. The three-dimensional imaging capability of CBCT reduced the effects of anatomical superimposition and geometric distortion, enabling improved visualization of lesion size, extent, and anatomical relationships.

Several studies emphasized the value of CBCT in evaluating complex anatomical regions and posterior teeth, where conventional radiographs often have limited diagnostic capability. CBCT also improved assessment of lesion boundaries, cortical bone involvement, and proximity to adjacent anatomical structures. These advantages resulted in enhanced diagnostic confidence and more accurate identification of periapical pathology.

DISCUSSION

This systematic review synthesized evidence from nine studies encompassing clinical, histopathological, cadaveric, and experimental investigations to evaluate the diagnostic accuracy of CBCT for detecting periapical lesions compared with conventional radiographic techniques. The findings consistently demonstrate that CBCT exhibits superior diagnostic performance across multiple metrics, including sensitivity, specificity, and overall accuracy, particularly for detecting small lesions, lesions confined to cancellous bone, and lesions located in anatomically complex regions. These results have important implications for endodontic diagnosis, treatment planning, and patient management.

The findings of this review align closely with recent meta-analyses examining CBCT's diagnostic performance. Abesi and Golikani conducted a comprehensive meta-analysis of eight studies and reported pooled sensitivity and specificity for CBCT of 94.6% (95% CI: 90.2–97.1) and 91.2% (95% CI: 81.7–96.0), respectively, with positive and negative predictive values of 93.0% and 92.3% [7]. In contrast, digital radiography demonstrated substantially lower sensitivity of 61.0% (95% CI: 38.3–79.8) and a negative predictive value of only 41.6% (95% CI: 28.0–56.6), indicating that conventional radiography fails to detect a considerable proportion of true periapical lesions [7]. The superior performance of CBCT was further corroborated by a recent systematic review evaluating imaging techniques for apical periodontitis diagnosis, which reported that periapical radiography showed low to moderate agreement with histopathological assessment, whereas CBCT demonstrated good agreement with histopathology, particularly for non-root-filled teeth [19].

The diagnostic advantages of CBCT are particularly pronounced in specific clinical scenarios. Consistent with previous reports, the included studies demonstrated that CBCT excels at detecting early-stage lesions and those confined to cancellous bone—pathologies that conventional radiography routinely misses due to the requirement of 30–50% bone mineral loss before radiographic visibility. Cotti and Schirru, in their comprehensive review of imaging techniques for periapical lesion detection, emphasized that CBCT is "the only system that ensures the early and predictable detection of all periapical lesions in the jaws, with the minor risk of false positives" [20]. This capability has direct clinical relevance, as delayed diagnosis of periapical pathology may lead to disease progression, persistent infection, and ultimately tooth loss.

The superior diagnostic accuracy of CBCT has meaningful implications for endodontic practice. Recent evidence from prognostic studies indicates that CBCT-detected pathology is significantly associated with root canal treatment outcomes. A meta-analysis by Mehta and colleagues reported that CBCT-identified periapical lesions were associated with a 2.63-fold increased odds of post-treatment failure (95% CI: 1.78–3.58; $p < 0.001$), while root fractures detected on CBCT demonstrated an even stronger association with failure (OR = 3.48; 95% CI: 2.05–5.12; $p < 0.001$) [21]. These findings underscore that accurate preoperative identification of periapical pathology and anatomical complexities using CBCT may improve treatment planning and prognostic counseling. The superior spatial resolution of CBCT has enabled precise quantitative assessments across diverse dental applications. For instance, Alqahtani et al., in a systematic review of maxillary expansion in adolescents, demonstrated that CBCT could reliably detect mean vertical changes as small as 0.9 mm with standard deviations of only 0.4 mm, a level of precision unattainable with conventional cephalometric radiography alone [22].

Furthermore, the ability of CBCT to identify lesions that are occult on conventional radiography has been shown to alter clinical decision-making. Studies have reported that approximately one-third of periapical lesions are missed on periapical radiographs when compared to CBCT, and lesions detected exclusively by CBCT frequently lead to modifications in endodontic diagnosis and treatment planning [23]. This is particularly relevant for complex cases involving multi-rooted teeth, posterior regions with anatomical

superimposition, and assessment of root canal treatment outcomes where conventional radiography may be inconclusive.

Despite the clear diagnostic advantages of CBCT, the potential for false-positive diagnoses warrants careful consideration. Pope and colleagues reported that 20% of vital, asymptomatic teeth exhibited widening of the periodontal ligament space on CBCT—an early radiographic predictor of apical periodontitis—raising concerns about potential overdiagnosis [24]. Similarly, Kruse et al. found that among teeth with periapical radiolucencies on CBCT that underwent apicoectomy, histopathological examination revealed no inflammatory infiltrate in 42% of cases, suggesting that CBCT may overestimate the presence of active periapical disease in some instances [25].

However, several methodological considerations temper these concerns. The study by Pope et al. used clinical symptoms as the sole reference standard for pulp vitality, which has been criticized as insufficiently rigorous [24]. More robust evidence from cadaveric studies using histopathology as the reference standard demonstrates a much lower risk of false positives. Kanagasingam and colleagues reported specificity of 1.0 for CBCT in detecting apical periodontitis in human cadavers, indicating a near-absence of false-positive diagnoses when histology serves as the gold standard [8]. Similarly, Kruse et al. (2018) found a very low risk of overdiagnosis for non-root-filled teeth and only a moderate risk for root-filled teeth in their cadaveric investigation [26].

The decision to utilize CBCT must balance diagnostic benefits against potential risks of ionizing radiation exposure. D'Albis and Capodiferro [27]argue that modern limited field-of-view CBCT protocols deliver effective doses in the range of 10–50 µSv, which compares favorably to a panoramic radiograph (10–30 µSv) and only modestly exceeds a series of multiple intraoral radiographs (1–5 µSv per image). For perspective, average daily background radiation exposure is approximately 8–10 µSv, and annual natural background exposure ranges from 2,000–3,000 µSv.

One of the main limitations of this systematic review is the considerable heterogeneity among the included studies. Variations were observed in study design, sample characteristics, lesion simulation methods, reference standards, CBCT imaging protocols, field of view settings, and reported diagnostic outcomes, which limited direct comparison across studies and precluded quantitative meta-analysis. Several included investigations were ex vivo, cadaveric, or animal studies, which may not fully replicate clinical conditions and could affect the generalizability of the findings. In addition, some studies used histopathological or surgical validation as reference standards, whereas others relied on comparative radiographic assessments, introducing methodological variability. Differences in observer experience, CBCT devices, voxel sizes, and image acquisition parameters may have also influenced diagnostic performance. Furthermore, only English-language publications were included, which may have introduced language bias. Despite these limitations, the included studies consistently demonstrated superior diagnostic performance of CBCT compared with conventional radiographic techniques for the detection of periapical lesions, supporting the overall reliability of the findings.

CONCLUSION

This systematic review demonstrated that cone-beam computed tomography (CBCT) consistently exhibits superior diagnostic performance compared with conventional radiographic techniques for the detection of periapical lesions and apical periodontitis. Across clinical, histopathological, cadaveric, and experimental studies, CBCT showed greater sensitivity, accuracy, and diagnostic confidence, particularly for small lesions, lesions confined to cancellous bone, and anatomically complex regions where conventional radiographs may be limited by structural superimposition and geometric distortion.

The available evidence suggests that CBCT provides more reliable three-dimensional visualization of periapical pathology, enabling earlier and more accurate detection of disease. However, variations in study design, reference standards, imaging protocols, and outcome measures highlight the need for greater methodological standardization in future research. Given considerations related to radiation exposure and cost, CBCT should be used judiciously and in accordance with current clinical guidelines, particularly in cases where conventional imaging is inconclusive or where additional diagnostic information is required. Overall, CBCT represents a valuable diagnostic adjunct in endodontics and offers significant advantages over conventional radiographic techniques for the assessment of periapical lesions.

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