



Diagnostic Accuracy of Cone-Beam Computed Tomography Versus Digital Periapical Radiography for Detection of Periapical Lesions: A Systematic Review

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KEYWORDS

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ABSTRACT:

Background: Digital periapical radiography (DPR) is widely used for periapical diagnosis but, as a two-dimensional projection, can underestimate small or cancellous-confined lesions. Cone-beam computed tomography (CBCT) may improve detection, although false positives and radiation considerations remain.

Objective: To compare the diagnostic accuracy of CBCT and DPR for detecting periapical lesions.

Methods: This review was registered in PROSPERO (CRD42024553116) and reported per PRISMA 2020. PubMed, Scopus, Embase, Web of Science, and the Cochrane Library were searched to July 2024 (English). Two reviewers independently screened records, extracted data, and assessed methodological quality using QUADAS-2. Diagnostic outcomes (sensitivity, specificity, predictive values, AUC) were synthesized narratively because of heterogeneity in design and reference standards.

Results: Fourteen studies from 10 countries were included (clinical observational/retrospective/prospective studies, one RCT, and in-vitro/ex-vivo models). The combined sample/specimen count was 2,518 (median 85; range 16–1,508). Most studies (12/14) reported higher lesion detection or overall diagnostic accuracy with CBCT than DPR, including superior performance across simulated defect sizes and additional management-relevant findings. CBCT sensitivity ranged 0.89–1.00 versus DPR 0.27–0.93; CBCT specificity ranged 0.571–1.00 versus DPR 0.70–0.99; AUC favoured CBCT (~0.753–0.943) over DPR (~0.584–0.629). QUADAS-2 highlighted frequent high/unclear risk from patient selection and reference standards. In histology subsets, CBCT overcalled while DPR missed disease occasionally.

Conclusions: CBCT generally improves detection and characterization of periapical pathology compared with DPR, but may reduce specificity in artefact-prone contexts. DPR should remain first-line; small-FOV CBCT is best reserved for equivocal cases, complex anatomy, retreatment, and surgical planning when three-dimensional information is expected to change management.

Introduction

Accurate identification of periapical disease underpins diagnosis, treatment planning, and outcome assessment in endodontics. Periapical lesions which are most commonly inflammatory sequelae of pulpal infection and are traditionally assessed with digital periapical radiographs (DPR) [1]. DPR is inexpensive, readily available, and delivers low radiation dose; however, as a two-dimensional projection it is susceptible to

anatomical superimposition, geometric distortion, and limited depiction of cancellous bone changes [2]. These constraints can reduce sensitivity for early or small lesions, for defects confined to the cancellous compartment, and in regions with complex anatomy such as posterior maxillae or multi-rooted teeth [2,3].

Cone-beam computed tomography (CBCT) offers three-dimensional visualization with isotropic voxels and high spatial resolution, potentially overcoming key



shortcomings of DPR [4]. Volumetric data permit multiplanar assessment of cortical perforation, lesion extent, and proximity to critical structures, and may reveal additional pathologies such as root fractures, resorption, or missed canals, that alter case management [5,6]. At the same time, CBCT introduces challenges such as higher radiation exposure than a single DPR (albeit variable and reducible via small field-of-view protocols), metallic and motion artefacts that can obscure apical regions or mimic pathology, greater cost, and more limited access [7,8]. Consequently, contemporary guidance emphasizes justification and optimization (ALARA/ALADA-IP), reserving CBCT for scenarios where three-dimensional information is expected to change clinical decisions.

Across the literature, head-to-head comparisons of CBCT and DPR for detecting periapical lesions report heterogeneous findings, influenced by study design (in vivo versus in vitro), reference standards (surgical inspection, histology, long-term clinical follow-up, or composite outcomes), voxel size and field-of-view, lesion size and location, and reader experience [7,9]. Although many studies suggest higher sensitivity for CBCT, the balance between true-positive gains and potential false positives from marrow spaces, nutrient canals, or artefact-related voids remains uncertain. Moreover, the clinical impact of additional CBCT detected lesions on treatment outcomes and whether detection translates into improved prognosis has not been consistently established [10].

Given these uncertainties and the need to align imaging choice with risk–benefit considerations, a rigorous synthesis of diagnostic accuracy evidence is warranted. This systematic review aims to evaluate and compare the accuracy of CBCT and DPR in diagnosing periapical lesions, summarizing sensitivity, specificity, likelihood ratios, and overall diagnostic performance, while exploring sources of heterogeneity such as reference standard, tooth type, jaw region, and CBCT acquisition parameters. By consolidating current evidence and appraising methodological quality, this review seeks to clarify when CBCT meaningfully augments DPR for periapical diagnosis and to inform evidence-based, patient-centred imaging decisions in endodontic practice.

Methodology

The protocol of the present systematic review is registered in the International Prospective Register of Systematic Reviews (PROSPERO) with reference ID CRD42024553116. The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [11].

Search Strategy

This systematic review was conducted to evaluate the accuracy of Cone Beam Computed Tomography (CBCT) compared to digital periapical radiographs (DPR) in diagnosing periapical lesions. A comprehensive search strategy was employed to identify relevant studies. Electronic databases, including PubMed, Scopus, Embase, Web of Science, and Cochrane Library, were searched for articles published up to July 2024. The search strategy included a combination of Medical Subject Headings (MeSH) terms and keywords related to CBCT, digital periapical radiographs, periapical lesions, and diagnostic accuracy. Boolean operators (AND, OR) were used to combine terms. A sample of the search string in PubMed is provided in Annexure. The search was limited to articles published in English. References from selected articles were also screened to identify additional relevant studies.

The initial search yielded about 2067 articles. After removing duplicates, titles and abstracts were screened independently by two reviewers to assess eligibility based on predefined inclusion and exclusion criteria. Full-text articles of potentially relevant studies were retrieved and further evaluated. Disagreements between reviewers were resolved through discussion or by involving a third reviewer. The final selection of studies was based on relevance to the research question and fulfillment of the inclusion criteria.

PICOS Criteria

The PICOS (Population, Intervention, Comparison, Outcome, and Study Design) framework was utilized to define the inclusion and exclusion criteria for this review. The criteria are detailed in the Table 1 below:



Table 1: PICOS Criteria for selection of articles in the present systematic review

Parameter	Inclusion Criteria	Exclusion Criteria
Population	<ul style="list-style-type: none"> - Patients diagnosed with or suspected of having periapical lesions. - All age groups, regardless of sex or ethnicity. 	<ul style="list-style-type: none"> - Studies involving animals or in vitro experiments. - Patients without periapical lesions. - Studies not involving human subjects.
Intervention	<ul style="list-style-type: none"> - Use of Cone Beam Computed Tomography (CBCT) for diagnosing periapical lesions. 	<ul style="list-style-type: none"> - Studies using other imaging modalities (e.g., MRI, CT, panoramic radiographs) without CBCT.
Comparison	<ul style="list-style-type: none"> - Comparison of CBCT with digital periapical radiographs (DPR). 	<ul style="list-style-type: none"> - Studies comparing CBCT with imaging modalities other than DPR. - Studies not including DPR as a comparator.
Outcome	<ul style="list-style-type: none"> - Diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. 	<ul style="list-style-type: none"> - Studies not reporting diagnostic accuracy outcomes. - Outcomes unrelated to periapical lesion diagnosis.
Study Design	<ul style="list-style-type: none"> - Randomized controlled trials (RCTs), cohort studies, case-control studies, cross-sectional studies, and observational studies. - Systematic reviews and meta-analyses providing original data or analyses. 	<ul style="list-style-type: none"> - Case reports, editorials, letters to the editor, and conference abstracts. - Non-peer-reviewed articles.

Data Extraction and Quality Assessment

Data from the included studies were extracted using a standardized data extraction form. The extracted data included study characteristics (author, year of publication, study design, sample size), patient demographics, details of the imaging modalities used, diagnostic outcomes (sensitivity, specificity, PPV, NPV, overall accuracy), and any reported limitations of the study.

The quality of the included studies was assessed independently by two reviewers using the [appropriate quality assessment tool, e.g., QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) tool [12]. This tool evaluates the risk of bias and applicability concerns across four domains: patient selection, index test, reference standard, and flow and timing. Each domain was rated as having a low, high, or unclear risk

of bias. Disagreements between reviewers were resolved through discussion or by involving a third reviewer.

Data Synthesis and Statistical Analysis

Data were synthesized qualitatively and, where possible, quantitatively through meta-analysis. Heterogeneity among the studies was assessed using the I^2 statistic. A random-effects model was used if significant heterogeneity was detected; otherwise, a fixed-effects model was applied. Sensitivity analysis was performed to explore the impact of study quality, sample size, and study design on the overall results. Publication bias was assessed using funnel plots and Egger's test.

A PRISMA flow diagram illustrating the study selection process is depicted in Figure 1.

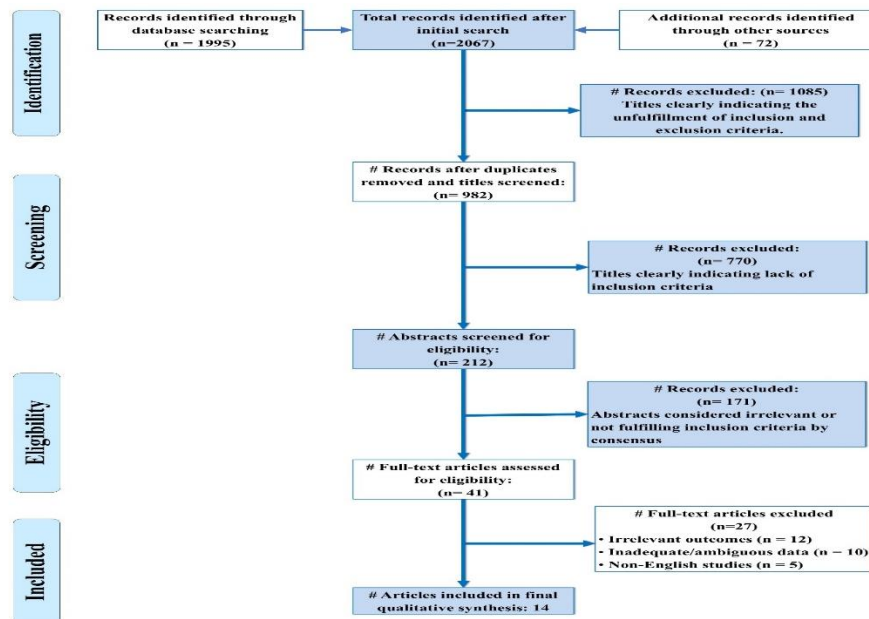


Figure 1: PRISMA Flow diagram indicating the selection process of the articles in the present systematic review

RESULTS

Results

Study selection and design characteristics

Fourteen studies were included (n=14) in the final systematic review (Figure 1) and the data extracted from these studies are tabularized in Table 2. The studies spanned across 10 countries (Sweden, Brazil, USA, Malaysia, Denmark, Italy, India, Pakistan, Indonesia, Latvia) [13-26]. Designs comprised observational (n=3; Hansen et al., Estrela; Kruse et al.), retrospective (n=1; Giudice et al.), randomized controlled trial (n=1; Srivastava et al.), prospective clinical (n=1; Keerthana et al.), clinical (n=1; Surya et al.), comparative cross-sectional (n=1; Pervez et al.),

cross-sectional (n=2; Yasa; Karkle et al.), in-vitro (n=3; Tsai et al.; Takeshita et al.; Kanagasingam et al.), and ex-vivo (n=1; Campello et al.) [13-26]. Aggregate sample size across all studies/specimens was 2,518 (n=2,518), with median 85 (range 16–1,508). Age was reported in 7/14 studies (n=7), spanning childhood to older adults (e.g., 11–90 years across Yasa; Kruse et al.; Surya et al.; Karkle et al.), and sex distribution was provided in 7/14 (n=7), including male–female counts or percentages (e.g., 21 M/75 F in Yasa; 62 M/58 F in Srivastava et al.). The anatomical region or tooth classes were explicitly stated in 7/14 (n=7), with several investigating both jaws and multiple tooth types (e.g., Hansen et al.; Campello et al.; Surya et al.; Yasa; Karkle et al.).

Author (Year)	Country	Study design	Sample size	Age	Gender	Area of examination	Parameters evaluated	Groups/Modalities	Key results	Conclusion
Hansen et al. (2007)	Sweden	Observational	46	16–80 y; mean 50	2 M, 3 F	All tooth types	PA lesion detection; lesion size; maxillary	Group 1: CBCT (3D Accuито	CBCT detected ≥ 10 more teeth and 33 more roots	In selected cases (e.g., negative PR but positive



[13]		tiona l			1 2 F	(I/C/ PM/ M)	sinus expansion; erosions/perforations; mucous membrane thickening; apical-marginal communication	mo); Group 2: two PRs	with PA lesions vs PR; 9× more erosions/perforations; sinus involvement 18 vs 13; mucous membrane thickening 4×; 5 more apical-marginal communications; clinically relevant additional info in 32/46 (70%)	clinical tests; planned endodontic surgery on multi-rooted teeth), 3D imaging is recommended
Estrela (2008) [14]	Brazil	Observationa l	1,508	NA	41% M , 59% F	NA	AP prevalence/accuracy	Group 1: CBCT (3D Accuito mo); Group 2: PR (IOPA); Group 3: OPG	Treated teeth—AP: 63.3% (CBCT) vs 35.3% (PR) vs 17.6% (OPG); untreated teeth—AP: 74.7% (CBCT) vs 36.1% (PR) vs 21.7% (OPG)	AP prevalence significantly higher on CBCT than PR/OPG; CBCT considered accurate for identifying AP
Tsai et al. (2012) [15]	USA (California)	In-vitro	16	NA	NA	NA	Specificity; AUC	Group 1: CBCT (Kodak 9000 3D); Group 2: CBCT (Veraviewpocs 3De); Group 3: PR	Specificity: 0.862 (G1), 0.892 (G2), 0.754 (G3); AUC: 0.767 (G1), 0.753 (G2), 0.584 (G3); CBCT > PR for AUC (significant)	CBCT outperforms PR for PA bone features; CBCT limitations must be considered during interpretation
Takeshita et al. (2014) [16]	Brazil	In-vitro	70	NA	NA	Mandible	ABL (CEJ→ABC) linear measurement	G1: CBCT; G2: OPG; G3: PR	Mean ABL (mm): Control 3.011; CBCT 3.085; OPG 2.754; PR	CBCT had means closest to control; Han-Shin method



							ent	digital PR; G4: IOPA (Rinn XCP); G5: IOPA (Han-Shin)	2.664; XCP 2.739; Han-Shin 2.244; Multiple pairwise differences significant, CBCT closest to control	differed most from control
Kanagasingam et al. (2016) [17]	Malaysia	In-vitro	67	NA	NA	Maxilla & mandible; anterior & posterior	AP detection	G1: CBCT; G2: DPR (central view); G3: DPRS (parallax)	Sensitivity: 0.89 (CBCT), 0.27 (DPR), 0.38 (DPRS); Specificity/PPV all ≈0.99; AUC: 0.943 (CBCT), 0.629 (DPR), 0.688 (DPRS)	All methods had similar specificity/PPV; CBCT superior; parallax increased PR accuracy
Campe llo et al. (2017) [18]	Brazil	Ex-vivo	110	NA	NA	Maxillary I/PM/M; Mandibular I/C/PM/M	PA lesion detection; diagnostic accuracy across defect sizes	G1: CBCT; G2: Digital PR	For no defect and for 0.6, 1.0, 1.4, 1.8 mm defects, CBCT accuracy > PR across multiple tooth types (numerous contrasts significant)	CBCT provided higher accuracy than PR for all simulated lesion sizes tested
Kruse et al. (2017) [19]	Denmark	Observational	74 (19 SER-R with histology)	M: 39–90 y; F: 31–80 y	NA	NA	PA status: radiographic (Rud & Molven) vs histology (SER-R subset)	G1: CBCT; G2: PR	CBCT–PR agreement 73% (54/74); disagreement 27% (20/74); PR false negatives 26% (5/19) in SER-R; CBCT false positives 42% (8/19) vs PR 11% (2/19); Correct diagnosis: 58% (CBCT)	CBCT showed more false positives (no histologic inflammation) while PR missed more true disease; Rud & Molven scores on CBCT correlated with histology (score 3: no inflammation;



									vs 63% (PR)	score 4: inflammation)
Giudice et al. (2018) [20]	Italy	Retrospective	101	NA	NA	NA	Diagnostic evidence for PA lesions and ancillary findings	G1: CBCT; G2: PR	CBCT uniquely identified: RF (n=3), IRR/ERR (n=3), untreated MB2 (n=23), lack of LC (n=10); PR missed many of these; for PA and treatment quality, CBCT showed more under-extended treatments and untreated anatomy	Some critical signs visible on CBCT are not evident on PR; CBCT recommended as a second-level exam
Srivastava et al. (2020) [21]	India	RCT	120	18–65 y	62 M, 58 F	NA	Diagnostic accuracy for PA lesions	G1: CBCT; G2: IOPA	Sensitivity: 92.5% (CBCT) vs 75.0% (IOPA); Specificity: 86.7% vs 70.0%; PPV: 89.3% vs 72.4%; NPV: 90.0% vs 74.6%	CBCT more effective than conventional radiography for detecting periapical lesions in symptomatic patients
Keerthana et al. (2021) [22]	India	Prospective clinical	112	18–59 y	45 M, 36 F (reported)	NA	Diagnostic accuracy for: PA lesion, alveolar bone defects, RR, RF, buccal cortical integrity	G1: CBCT; G2: IOPA (Rinn XCP-DS)	CBCT showed higher overall accuracy for complex endodontic pathoses vs PR, except for bone defect diagnosis where PR performed comparably	Overall, CBCT superior to PR for complex pathoses; bone-defect detection comparable



Surya et al. (2022) [23]	India	Clinical	50	48.7 ± 3.86 y	27 M, 11 F	Maxilla & mandible; I/PM/M	PA diagnosis (five-point scale; CBPAI index)	G1: CBCT; G2: DPR	Five-point scale: 4.82 ± 0.57 (CBCT) vs 4.31 ± 1.25 (DPR), p=0.004; CBPAI: 3.39 ± 1.56 (CBCT) vs 2.04 ± 1.93 (DPR), p<0.0001	3D CBCT is more accurate than 2D imaging for PA, especially in multi-rooted teeth
Pervez et al. (2023) [24]	Pakistan	Comparative cross-sectional	105	NA	NA	NA	Diagnostic accuracy for PA lesions (post-endodontic)	G1: CBCT; G2: DPR; G3: NA	CBCT vs DPR lesion count: 69 vs 41; CBCT: Sn 1.00, Sp 0.571, PPV 0.718; OR for detection CBCT > DPR by 1.7×	CBCT shows better accuracy than IOPA for detecting periapical radiolucency in post-endodontic cases
Yasa (2023) [25]	Indonesia	Cross-sectional	96	M: 27–84 y; F: 11–76 y	21 M, 75 F	Maxilla & mandible; I/C/PM/M	PAI distribution; PR accuracy metrics	G1: CBCT; G2: PR	PAI 1–2 (absent): 108 roots (CBCT) vs 131 (PR); PAI 3–5 (present): 97 (CBCT) vs 74 (PR); PR accuracy: Sn 0.65, Sp 0.90, PPV 0.86, NPV 0.75	PR shows lower sensitivity vs CBCT; CBCT provides more detailed endodontic information
Karkle et al. (2024) [26]	Latvia	Cross-sectional	43	43.1 ± 14.6 y	NA	Maxilla & mandible; I/C/PM	Method comparison (measurement differences); sensitivity; GEE	G1: CBCT; G2: PR; G3: USG	Mean difference: CBCT–PR 0.61 mm; CBCT–USG 0.99 mm; PR–USG no difference (p=0.193); Sn: 97.7%	PR detects pathoses with minimal radiation and can measure/characterize PA lesions; CBCT is most precise but



							analysis		(CBCT), 93% (PR), 76.7% (USG); GEE significant	radiation-intensive; reserve for complex cases
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Index and comparator modalities; reference standards

All studies compared CBCT with periapical radiography (PR/IOPA) (n=14) [13-26]. Additional comparators included OPG (n=2; Estrela; Takeshita et al.), DPR with parallax views (n=1; Kanagasingam et al.), ultrasonography (n=1; Karkle et al.), and IOPA positioning variants (Rinn XCP and Han-Shin) (n=1; Takeshita et al.) [14,16,17,26]. A formal histopathologic reference standard was used in one full in-vitro study (n=1; Kanagasingam et al.) and in a surgical retreatment subset (n=1; Kruse et al., 19 teeth), while most relied on radiographic/clinical endpoints or composite references (n=12)[17,19].

Primary diagnostic outcome: periapical lesion detection/diagnostic accuracy

Periapical detection/diagnostic accuracy constituted the primary outcome in 13/14 studies (n=13), with one study focusing primarily on linear alveolar bone loss measurement accuracy (n=1; Takeshita et al.) [13-26]. Across studies directly comparing modalities, CBCT detected more lesions or provided higher diagnostic accuracy than PR in the majority (n=12), including large cohorts (e.g., Estrela) and controlled settings (e.g., Campello et al.) [14,18]. Estrela reported markedly higher apical periodontitis prevalence on CBCT versus PR and OPG in both treated and untreated teeth (p<0.001), while Campello et al. demonstrated superior CBCT accuracy versus PR across simulated defects from 0.6–1.8 mm (p values spanning <0.05 to <0.01)[14,18]. In complex endodontic presentations, Keerthana et al. found CBCT overall more accurate than PR, with the exception of alveolar bone defect diagnosis where performance was comparable [22]. One clinical cohort highlighted a trade-off: Kruse et al. observed more CBCT false positives against histology in a surgical subset, while PR missed more true disease (false negatives), with overall “correct diagnosis” proportions of 58% (CBCT) and 63% (PR) in that specific context [19].

Sensitivity, specificity, predictive values, and AUC

Sensitivity was reported in 5 studies (n=5). For CBCT, sensitivity ranged from 0.89 to 1.00 (Kanagasingam et al.; Srivastava et al.; Pervez et al.; Karkle et al.), while PR sensitivity ranged from 0.27 to 0.93 (Kanagasingam et al.; Srivastava et al.; Yasa; Karkle et al.) [17,21,24,25,26]. Specificity was reported in 6 studies (n=6). CBCT specificity spanned 0.571–1.000 (Pervez et al.; Srivastava et al.; Tsai et al.; Kanagasingam et al.), and PR specificity 0.70–0.99 (Srivastava et al.; Tsai et al.; Kanagasingam et al.; Yasa) [15,17,21,24,25]. Positive and negative predictive values were available in 4 studies (n=4), with CBCT PPV generally ≥ 0.72 and NPV up to 0.90 (Srivastava et al.; Pervez et al.; Yasa; Kanagasingam et al.) [17,21,24,25]. Area-under-the-curve (AUC) was reported in 2 in-vitro studies (n=2): CBCT AUC ranged ~0.753–0.943 versus PR ~0.584–0.629 (Tsai et al.; Kanagasingam et al.), with parallax PR modestly improving AUC over single-view PR (0.688 vs 0.629 in Kanagasingam et al.) [15,17].

Quantitative and scale-based outcomes

Where formal scales or indices were used (n=3), CBCT yielded higher scores consistent with greater lesion conspicuity. Surya et al. showed higher five-point lesion assessment scores (mean 4.82 vs 4.31, p=0.004) and higher CBPAI values (3.39 vs 2.04, p<0.0001) for CBCT versus DPR [22]. Kruse et al. applied Rud & Molven categories and linked CBCT scores with histologic status in surgically retreated teeth. Yasa reported PAI distributions favoring higher detection with CBCT (PAI 3–5 present: 47% CBCT vs 36% PR) and quantified PR accuracy (sensitivity 0.65; specificity 0.90; PPV 0.86; NPV 0.75) [19].

Measurement agreement and size effects

Measurement-oriented outcomes were reported in 2 studies (n=2). Takeshita et al. found CBCT linear alveolar bone loss measurements (CEJ→ABC) closest to the true control (mean 3.085 mm vs control 3.011



mm), outperforming OPG and PR, while the Han-Shin IOPA method deviated most from control. Karkle et al. reported method differences in lesion measurement (mean difference CBCT–PR = 0.61 mm; CBCT–USG = 0.99 mm) and sensitivities of 97.7% (CBCT), 93.0% (PR), and 76.7% (USG), with generalized estimating equations indicating significant between-method effects ($p < 0.001$) [16,26].

Ancillary and management-relevant findings

Ancillary findings were detailed in 2 clinical series ($n=2$). Hansen et al. reported that CBCT provided clinically relevant additional information in 70% of cases ($n=32/46$), including erosions/perforations and sinus extension not appreciated on PR [13]. Giudice et al. catalogued management-relevant findings uniquely identified on CBCT untreated MB2 canals ($n=23$), lack of lateral canal treatment ($n=10$), root fractures ($n=3$), and internal/external resorption ($n=3$) that were frequently missed on PR, while also quantifying greater identification of under-extended endodontic treatments on CBCT [20].

Statistical significance reporting

Formal hypothesis tests were reported in 8 studies ($n=8$), most showing statistically significant advantages for CBCT over PR on primary accuracy/detection outcomes (e.g., Estrela $p < 0.001$; Kanagasingam et al. $p < 0.0001$; Campello et al. $p < 0.05$ to $p < 0.01$; Srivastava et al. $p < 0.05$; Keerthana et al. $p = 0.01–0.03$ across endpoints; Surya et al. $p = 0.004$ and $p < 0.0001$; Karkle et al. $p < 0.001$), with one instance of no significant difference for a specific PR–USG comparison (Karkle et al., $p = 0.193$) [14,17,18,21,22,23,26].

Overall, across heterogeneous designs and settings, the preponderance of evidence favored CBCT over PR for the detection and characterization of periapical pathology ($n \approx 12/14$), while selected contexts highlighted potential CBCT overcalls against histology (Kruse et al.) or comparable performance for specific bony defects (Keerthana et al.) [19,22].

Risk of bias:

The QUADAS-2 appraisal indicated that most included studies were limited primarily by non-definitive

reference standards and suboptimal patient selection [12]. Eleven of fourteen studies relied on composite clinical/radiographic endpoints or partial verification rather than uniform surgical/histologic confirmation, introducing the potential to overestimate accuracy, particularly sensitivity, for the index test [13–26]. Spectrum issues were frequent: several observational/retrospective cohorts used enriched or convenience samples, and all in-vitro/ex-vivo experiments, while internally valid, have reduced clinical generalisability. Reporting of index-test conduct was often incomplete, with unclear blinding to the comparator/reference and variably prespecified thresholds, whereas flow/timing was generally acceptable because CBCT and DPR were obtained in close succession. Applicability concerns were therefore highest for patient selection and reference standard; by contrast, the index test itself (CBCT/DPR) aligned well with real-world practice.

Interpreted alongside these risks, the consistent direction of effect favouring CBCT across heterogeneous designs supports a moderate level of confidence in the qualitative conclusion that CBCT detects more periapical disease than DPR. However, absolute estimates of sensitivity/specificity likely reflect some upward bias in studies without rigorous verification, and the few histology-anchored datasets highlight trade-offs; for example, more false positives with CBCT in a surgical subset (Kruse et al.) contrasted with excellent sensitivity in a histology-validated model (Kanagasingam et al.) and superior accuracy across simulated defects (Campello et al.). Clinically, this argues for selective, indication-driven CBCT use rather than routine screening, and for cautious interpretation in artefact-prone contexts. Future studies should reduce “High/Unclear” ratings by standardising acquisition and reading protocols, ensuring blinded interpretation, applying balanced reference standards across test-result strata, and linking imaging-based reclassification to patient-centred outcomes, dose, and cost—thereby strengthening both internal validity and applicability to everyday endodontic care.



Sr. No.	Author (Year)	Risk of Bias – Patient Selection	Risk of Bias – Index Test	Risk of Bias – Reference Standard	Risk of Bias – Flow & Timing	Applicability – Patient Selection	Applicability – Index Test	Applicability – Reference Standard
1	Hansen et al. (2007) [13]	High	Unclear	High	Unclear	High	Low	High
2	Estrela (2008) [14]	High	Unclear	High	High	High	Low	High
3	Tsai et al. (2012) [15]	High	Unclear	Low	Low	High	Low	Low
4	Takeshita et al. (2014) [16]	High	Unclear	Low	Low	High	High	Low
5	Kanagasingam et al. (2016) [17]	High	Low	Low	Low	High	Low	Low
6	Campello et al. (2017) [18]	High	Low	Low	Low	High	Low	Low
7	Kruse et al. (2017) [19]	High	Unclear	High	High	High	Low	High
8	Giudice et al. (2018) [20]	High	Unclear	High	Unclear	High	Low	High
9	Srivastava et al. (2020) [21]	Low	Unclear	High	Low	Low	Low	High
10	Keerthana et al. (2021) [22]	Unclear	Unclear	High	Low	Unclear	Low	High
11	Surya et al. (2022) [23]	Unclear	Low	High	Low	Low	Low	High
12	Pervez et al. (2023) [24]	Unclear	Unclear	High	Low	Unclear	Low	High
13	Yasa (2023) [25]	Unclear	Low	High	Low	Low	Low	High
14	Karkle et al. (2024) [26]	Unclear	Low	High	Low	Unclear	Low	High

Discussion

This review synthesizes evidence across fourteen studies and shows a consistent pattern of CBCT generally detects more periapical disease and characterizes lesions more completely than DPR. The

large observational cohort by Estrela demonstrated substantially higher apparent prevalence of apical periodontitis on CBCT than on DPR or panoramic views, underscoring the modality's greater conspicuity for cancellous-confined lesions and small cortical breaches [14]. Experimental work supports this signal:



in *ex vivo* models spanning defect sizes from 0.6–1.8 mm, CBCT achieved higher diagnostic accuracy than DPR across tooth types (Campello et al.), while *in vitro* ROC analyses showed CBCT AUC exceeding that of DPR and improving further with optimized devices (Tsai et al.; Kanagasingham et al.) [15,17,18]. Clinically, CBCT also uncovered management-relevant findings frequently missed on DPR, such as untreated MB2 canals, resorption, and under-extended root fillings suggesting a tangible impact on treatment planning [20]. In routine endodontic practice, CBCT provided additional clinically relevant information in 70% of cases in a mixed population, particularly when DPR was equivocal or surgery was contemplated [13].

The scientific basis for these differences is clear. DPR projects three-dimensional structures onto a two-dimensional plane, raising the detection threshold for early marrow space osteolysis and inviting superimposition artefacts; by contrast, CBCT samples isotropic voxels that permit thin-slice multiplanar viewing around the apex, revealing trabecular rarefaction before overt cortical involvement [27]. Yet the same physics introduce pitfalls: high-density materials can generate beam-hardening streaks, and normal anatomic channels may mimic disease, which helps explain reports of lower specificity in certain contexts. In a surgical retreatment subset with histology, CBCT produced more false positives whereas DPR produced more false negatives, yielding similar proportions of “correct diagnoses” overall in that narrow scenario [19,28]. Post-endodontic cohorts likewise showed CBCT sensitivity reaching 1.00 with modest specificity, reinforcing the need for disciplined interpretive criteria when metallic restorations or sealer are present [24]. Notably, performance advantages were not universal across endpoints: for linear measurement of alveolar bone loss, CBCT aligned most closely with true values, but one clinical study found bone-defect detection comparable between modalities [16,22].

Several limitations temper these conclusions. Heterogeneity in design (*in vitro*, *ex vivo*, observational, randomized), reference standards (histology, surgery, composite clinical follow-up), acquisition parameters (field of view, voxel size, kVp/mA, artefact-reduction algorithms), and reader calibration likely contributed to variance in accuracy estimates. Blinding and allocation/reporting domains

were not uniformly robust, and verification bias is possible where DPR-negative cases were less likely to receive definitive confirmation. Few studies linked imaging-based reclassification to patient-centred outcomes, leaving uncertain the extent to which additional CBCT-only findings translate into improved healing or reduced retreatment [13-26].

Future research should prioritize prospective, multicentre diagnostic-accuracy studies with standardized CBCT protocols and STARD-compliant reporting, incorporate rigorous reference standards across all test-result strata, and quantify management and outcome consequences of CBCT-guided decisions. Work on dose-optimized, small-FOV protocols, explicit interpretive thresholds (e.g., CBPAI), reader-training frameworks, and cost-effectiveness analyses is needed to balance incremental diagnostic yield against radiation and resource use. Advances in artefact mitigation and decision support (e.g., radiomics/AI for specificity) may further refine when CBCT meaningfully augments DPR in endodontic diagnosis.

Conclusion

This systematic review indicates that cone-beam computed tomography (CBCT) generally outperforms digital periapical radiography (DPR) for detecting and characterizing periapical pathology, particularly in cancellous-confined lesions, multirooted teeth, and anatomically complex regions where two-dimensional superimposition limits DPR. CBCT also reveals ancillary, management-relevant findings (e.g., untreated anatomy, resorption, cortical breaches) that can alter treatment planning; however, these benefits must be weighed against higher radiation dose, greater cost, artefact-related false positives, and variable access. Given heterogeneous study designs, nonuniform reference standards, and occasional concerns about blinding and verification, the evidence supports a selective, indication-driven strategy: DPR remains the first-line, low-dose screen, while small-FOV CBCT should be reserved for equivocal cases, suspected cancellous-only disease, obscured apices or retreatment, and surgical planning where three-dimensional detail is expected to change management. Standardized acquisition/interpretation protocols and prospective outcome-linked studies are needed to clarify when



CBCT's incremental diagnostic yield translates into meaningful improvements in patient prognosis.

References

1. Wei LX, Min FH, Zaharuddin SZ, Ling EK, Suresh KV, Abd Muttalib K, Dicksit DD. Radiographic assessment of apical root resorption in inflammatory periapical pathologies. *J Indian Acad Oral Med Radiol.* 2018;30:132-6. 10.4103/jiaomr.jiaomr_71_17
2. Yapp KE, Brennan P, Ekpo E. Endodontic disease detection: digital periapical radiography versus cone-beam computed tomography—a systematic review. *J Med Imaging (Bellingham).* 2021;8:041205. 10.1117/1.JMI.8.4.041205
3. Cotti E, Schirru E. Present status and future directions: imaging techniques for the detection of periapical lesions. *Int Endod J.* 2022;55:1085-99. 10.1111/iej.13828
4. Kaur K, Saini RS, Vaddamanu SK, Bavabeedu SS, Gurumurthy V, Sainudeen S, et al. Exploring technological progress in three-dimensional imaging for root canal treatments: a systematic review. *Int Dent J.* 2025;75:1097-112. 10.1016/j.identj.2024.05.014
5. Morgan N, Meeus J, Shujaat S, Cortellini S, Bornstein MM, Jacobs R. CBCT for diagnostics, treatment planning and monitoring of sinus floor elevation procedures. *Diagnostics (Basel).* 2023;13:1684. 10.3390/diagnostics13101684
6. Ng SY. The three-dimensional nature of a dental CBCT scan. In: *Cone beam CT in dentistry: an atlas for dentists and medical radiologists.* Cham: Springer International Publishing; 2023. p. 1-43. 10.1007/978-3-031-25480-2_1
7. MacDonald D, Telyakova V. An overview of cone-beam computed tomography and dental panoramic radiography in dentistry in the community. *Tomography.* 2024;10:1222-37. 10.3390/tomography10080092
8. Alshomrani F. Cone-beam computed tomography (CBCT)-based diagnosis of dental bone defects. *Diagnostics (Basel).* 2024;14:1404. 10.3390/diagnostics14131404
9. Magat G, Oncu E, Ozcan S, Orhan K. Comparison of cone-beam computed tomography and digital panoramic radiography for detecting peri-implant alveolar bone changes using trabecular micro-structure analysis. *J Korean Assoc Oral Maxillofac Surg.* 2022;48:41-9. 10.5125/jkaoms.2022.48.1.41
10. Braun MJ, Rauneker T, Dreyhaupt J, Hoffmann TK, Luthardt RG, Schmitz B, et al. Dental and maxillofacial cone beam CT—high number of incidental findings and their impact on follow-up and therapy management. *Diagnostics (Basel).* 2022;12:1036. 10.3390/diagnostics12051036
11. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ.* 2021;372:n160. <https://doi.org/10.1136/bmj.n160>
12. Huang QX, Huang XW. QUADAS-2 tool for quality assessment in diagnostic meta-analysis. *Ann Palliat Med.* 2022;11:1844-5. 10.21037/apm-22-204
13. Lofthag-Hansen S, Huuonen S, Gröndahl K, Gröndahl HG. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2007;103:114-9. 10.1016/j.tripleo.2006.01.001
14. Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. *J Endod.* 2008;34:273-9. 10.1016/j.joen.2007.11.023
15. Tsai P, Torabinejad M, Rice D, Azevedo B. Accuracy of cone-beam computed tomography and periapical radiography in detecting small periapical lesions. *J Endod.* 2012;38:965-70. 10.1016/j.joen.2012.03.001
16. Takeshita WM, Iwaki LC, da Silva MC, Sabio S, Albino PR. Comparison of periapical radiography with cone beam computed tomography in the diagnosis of vertical root fractures in teeth with metallic post. *J Conserv*



- Dent Endod. 2014;17:225-9. 10.4103/0976-237X.137930
17. Kanagasingam S, Lim CX, Yong CP, Mannocci F, Patel S. Diagnostic accuracy of periapical radiography and cone beam computed tomography in detecting apical periodontitis using histopathological findings as a reference standard. *Int Endod J.* 2017;50:417-26. 10.1111/iej.12650
 18. Campello AF, Gonçalves LS, Guedes FR, Marques FV. Cone-beam computed tomography versus digital periapical radiography in the detection of artificially created periapical lesions: a pilot study of the diagnostic accuracy of endodontists using both techniques. *Imaging Sci Dent.* 2017;47:25-31. 10.5624/isd.2017.47.1.25
 19. Kruse C, Spin-Neto R, Evar Kraft DC, Vaeth M, Kirkevang LL. Diagnostic accuracy of cone beam computed tomography used for assessment of apical periodontitis: an ex vivo histopathological study on human cadavers. *Int Endod J.* 2019;52:439-50. 10.1111/iej.13020
 20. Lo Giudice R, Nicita F, Puleio F, Alibrandi A, Cervino G, Lizio AS, et al. Accuracy of periapical radiography and CBCT in endodontic evaluation. *Int J Dent.* 2018;2018:2514243. 10.1155/2018/2514243
 21. Srivastava R, Singh P, Mehrotra V, Garg K, Kushwaha S. Diagnostic accuracy of cone beam computed tomography in detecting periapical lesions: a clinical study. *J Cardiovasc Dis Res.* 2020;11:68-77. 10.48047/
 22. Singh N, Yadav R, Duhan J, Tewari S, Gupta A, Sangwan P, et al. Comparative analysis of the accuracy of periapical radiography and cone-beam computed tomography for diagnosing complex endodontic pathoses using a gold standard reference: a prospective clinical study. *Int Endod J.* 2021;54:1418-28. 10.1111/iej.13535
 23. Surya S, Barua AN, Magar SP, Magar SS, Rela R, Chhabada AK. Comparative assessment of the efficacy of two-dimensional digital intraoral radiography to three-dimensional cone beam computed tomography in the diagnosis of periapical pathologies. *J Pharm Bioallied Sci.* 2022;14:S1009-13. 10.4103/jpbs.jpbs_810_21
 24. Pervez J, Adil HM, Zafar I, Rana MA, Akram A. Accuracy of cone beam computed tomography in endodontics: a study of comparison of CBCT vs. digital intra-oral periapical radiographs in the evaluation of periapical radiolucency in endodontics. *Pak Oral Dent J.* 2023;43:149-53.
 25. Yasa IP, Nasutianto H, Okano T. Diagnostic accuracy of periapical radiolucency using periapical radiography and cone-beam computed tomography. *J Radiol Dentomaxillofac Indones.* 2023;7:1-8. 10.32793/jrdi.v7i1.934
 26. Karkle A, Slaidina A, Zolovs M, Vaskevica A, Meistere D, Bokvalde Z, et al. Comparative analysis of examination methods for periapical lesion diagnostics: assessing cone-beam computer tomography, ultrasound, and periapical radiography. *Diagnostics (Basel).* 2024;14:766. 10.3390/diagnostics14070766
 27. Wen KC, Wee LC, Wei M, Gerald LK, Yu VS. 2D versus 3D radiographic assessment of asymptomatic persistent endodontic lesions. *Int Endod J.* 2025. 10.1111/iej.14272
 28. Aung NM, Myint KK. Diagnostic accuracy of CBCT for detection of second canal of permanent teeth: a systematic review and meta-analysis. *Int J Dent.* 2021;2021:1107471. 10.1155/2021/1107471
- Annexure:
- Search: (((digital radiography) OR (periapical radiography)) AND ((cone beam computed tomography) OR (CBCT)) AND (accuracy) AND (diagnosis) AND ((periapical lesions) OR (periapical pathology))))
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Translations

digital: "digitalisation"[All Fields] OR "digitalised"[All Fields] OR "digitalization"[All Fields] OR "digitalize"[All Fields] OR "digitalized"[All Fields] OR "digitalizer"[All Fields] OR "digitalizing"[All Fields] OR "digitally"[All Fields] OR "digitals"[All Fields] OR "digitization"[All Fields] OR "digitizations"[All Fields] OR "digitize"[All Fields] OR "digitized"[All Fields] OR "digitizer"[All Fields] OR "digitizers"[All Fields] OR "digitizes"[All Fields] OR "digitizing"[All Fields] OR "radiographic image enhancement"[MeSH Terms] OR ("radiographic"[All Fields] AND "image"[All Fields] AND "enhancement"[All Fields]) OR "radiographic

image enhancement"[All Fields] OR "digital"[All Fields]

periapical: "periapical"[All Fields] OR "periapically"[All Fields] OR "periapicals"[All Fields]

radiography: "diagnostic imaging"[Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "radiography"[All Fields] OR "radiography"[MeSH Terms] OR "radiographies"[All Fields] OR "radiographys"[All Fields]

cone beam computed tomography: "cone-beam computed tomography"[MeSH Terms] OR ("cone-beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "cone-beam computed tomography"[All Fields] OR ("cone"[All Fields] AND "beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "cone beam computed tomography"[All Fields]

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periapical: "periapical"[All Fields] OR "periapically"[All Fields] OR "periapicals"[All Fields]

lesions: "lesion"[All Fields] OR "lesion's"[All Fields] OR "lesional"[All Fields] OR "lesions"[All Fields]

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pathology: "pathology"[MeSH Terms] OR "pathology"[All Fields] OR "pathologies"[All Fields] OR "pathology"[Subheading]