A Clinical Decision Support System for Endodontic Case Assessment and Referral Using Multimodal Artificial Intelligence: Proof of Concept

Abstract

Background:
Accurate diagnosis and assessment of procedural difficulty are central to effective endodontic decision-making. Despite established clinical guidelines, variability in radiographic interpretation, inconsistent use of diagnostic terminology, and challenges in referral communication continue to influence clinical outcomes. Structured digital decision support may help reduce variability in endodontic diagnosis, assessment of case difficulty, and referral communication.

Aim:
To describe the development and methodological framework of an artificial intelligence–assisted clinical decision support system (CDSS) for endodontic case assessment and to evaluate agreement between a structured clinical decision support system for endodontic case assessment and independent expert endodontist judgement.

Materials and Methods:
A web-based clinical decision support system was developed to integrate structured clinical data, radiographic analysis, and guideline-based reasoning. Diagnostic terminology and decision logic were aligned with recommendations from the American Association of Endodontists, the European Society of Endodontology, and the International Association of Dental Traumatology. The system was designed to generate structured, editable digital prescriptions incorporating diagnosis, assessment of case difficulty, treatment considerations, and referral recommendations. Sixty anonymised simulated endodontic cases were entered into a previously developed clinical decision support system. Thirty cases were entered by an endodontist and thirty by a general dental practitioner. System-generated diagnostic and treatment assessments were independently reviewed by two blinded endodontists using standardised diagnostic terminology. Independent expert judgement served as the reference standard.

Results:
The system enables structured capture of patient history, clinical findings, sensibility testing, and radiographic features, synthesising these inputs into guideline-aligned assessments. Outputs are presented in a transparent format that supports clinician review and modification. Agreement with the expert reference standard ranged from 83 per cent to 97 per cent. Inter-operator agreement between reviewers was 95 per cent. Discrepancies were primarily associated with incomplete clinical information.

Conclusion:
This clinical decision support system represents a structured approach to integrating multimodal clinical information into endodontic decision-making while preserving clinician oversight. The system demonstrated close alignment with expert judgement in this

exploratory evaluation. Structured digital prescriptions may support consistent diagnostic reasoning while preserving clinician oversight. The application can be accessed on https://rootcanalai.vercel.app.

Keywords: Artificial intelligence; Beta testing; Clinical decision support; Diagnosis; Referral.

Keywords:
Artificial Intelligence; Endodontics; Clinical Decision Support; Multimodal Imaging; Referral Workflow; Diagnosis; Case Difficulty; Treatment Planning.

Introduction

Accurate diagnosis and treatment of pulp and periapical diseases need careful clinical assessment. Accurate diagnosis of pulpal and periapical disease requires a synthesis of clinical history, subjective symptoms, objective testing and careful examination of radiographic findings. Radiographs may reveal subtle or ambiguous findings, and practitioners frequently differ in interpreting periapical changes, lamina dura integrity or early-stage bone loss. Several studies have illustrated how interpretation varies even among specialists, who may disagree on whether a radiolucency represents true periapical disease or a normal anatomical variant[1–3]. These inconsistencies reflect the inherent difficulty of working with two-dimensional images and the variability of clinical presentations.

In response to this challenge, professional organisations have attempted to standardise diagnostic terminology and promote uniform reasoning. The AAE Consensus Diagnostic Terminology remains one of the most widely adopted frameworks for this purpose [4], while the more recent S3-level European Society of Endodontology guidelines provide a structured evidence-based pathway for diagnosing and managing pulpal and periapical disease [5]. The AAE Case Difficulty Assessment Form, now available in both static and digital formats, reinforces this standardisation effort by helping clinicians judge when a case may exceed their comfort level or fall outside the scope of routine care [6-12]. The Endodontic Complexity Assessment Tool (E-CAT) also contributes to this movement by offering a validated digital approach to difficulty classification, demonstrating that structured scoring can improve consistency among clinicians [7].

At the same time, advances in artificial intelligence have encouraged exploration of whether structured digital systems might support more reliable diagnostics. Deep learning models have shown promise in detecting periapical lesions on periapical radiographs, CBCT scans and panoramic images [8–10,14–16]. Studies comparing these systems to human observers suggest that well-trained models may match or occasionally exceed human sensitivity, although performance can fluctuate when images differ in quality, orientation or anatomical complexity [9, 15-22]. Broader reviews in dentistry note similar trends: while AI can assist with image interpretation, meaningful clinical decisions depend on achieving reliable integration of clinical findings, radiographic features and contextual information [17–19, 23–26]. Ethical

considerations, including transparency and the preservation of clinician autonomy, remain central to the discussion [27,28].

Interest in digital decision-support also reflects a wider shift in endodontic research and practice. Recent bibliometric work shows rapid expansion in both the volume and thematic diversity of endodontic publications, particularly in areas related to imaging, computational modelling and outcome prediction [13]. Research groups continue to explore how machine learning can contribute to tasks such as predicting surgical difficulty, analysing CBCT lesions or estimating treatment prognosis [29–31]. These developments have raised expectations that digital tools may one day help streamline diagnosis, aid in planning and improve communication between providers.

The clinical decision-support system evaluated in this study was developed with these goals in mind. It integrates structured data entry, radiographic analysis, case difficulty scoring and referral communication into a single workflow. The intention was not to replace clinical judgement, but to create a tool that aligns with existing guidelines, supports consistency and encourages thorough documentation. Because meaningful validation requires comparison to expert interpretation, the present study compares system-generated assessments with those of blinded endodontists. The findings offer a preliminary look at how such a system may function in practice.

Methodology

Study Design

This investigation followed an exploratory framework aimed at evaluating a proof-of-concept clinical decision support system (CDSS) developed to assist in endodontic diagnosis, case difficulty assessment and referral planning. The system emulates a complete clinical workflow by guiding practitioners through structured data entry, radiographic interpretation and guideline-aligned reasoning. Because the purpose of this initial study was to determine whether the platform could generate assessments consistent with specialist judgement, the evaluation relied on beta testing using anonymised patient-derived clinical data with random names and personal details and agreement between AI-supported assessment and blinded endodontist reviewers was assessed (Figure 1).

System Architecture and Workflow

The platform was constructed as a browser-based application using React (version 18.2.0) and TypeScript, with Tailwind CSS adopted to support a responsive interface. All computational processes operate on the client side, and local storage simulates data persistence so that the platform can function without a server. The workflow is role-dependent; users identify themselves as general dental practitioners, endodontists or specialists at registration, and the corresponding interface tailors data entry, case management and referral capabilities to their clinical responsibilities.

Once a case is opened, the workflow progresses through sequential prompts for patient history, symptoms, clinical findings and imaging. Tooth identification is performed through an interactive chart, and clinicians may record details such as percussion or palpation

sensitivity, periodontal status, swelling and restorability. Uploaded radiographs and DICOM files form the basis for the imaging analysis components. All data populate a structured case object that remains consistent across assessment and referral modules.

Data Input and Case Processing

The platform supports multimodal inputs to mirror the range of information used in endodontic decision-making. Users may enter demographic and medical information, details of the chief complaint, narrative history, results of sensibility or tenderness testing and periodontal characteristics. Voice-to-text dictation is available for those preferring verbal documentation. Radiographs in JPEG or PNG formats, as well as DICOM files for CBCT analysis, are accepted.

The AAE Case Difficulty Assessment Form is embedded within the workflow. Selected difficulty factors are captured and weighted automatically, permitting classification into minimal, moderate or high difficulty categories. A high difficulty designation initiates a referral recommendation within the generated report.

The system helps with case assessment, treatment planning, and workflow. (Figure 2). The role-based system ensures users access features relevant to their clinical function. (Figure 3). All clinical inputs are consolidated into a structured patient data object, forming the foundation for case assessment and reasoning. (Figure 4). The reports include: radiographic analysis, clinical assessment, treatment planning, medication guidelines and referral recommendations. This approach ensures uniformity and facilitates clinician validation (Figure 5) and generate a structured, text-based analysis of the radiograph (Figure 6)

Diagnostic and Decision Support Algorithms

The CDSS integrates language and imaging models from Google's Gemini platform. Clinical narratives are processed through gemini-2.5-flash, while radiographic interpretation uses gemini-2.5-flash-image. These analyses are guided by prompting strategies constructed around authoritative professional frameworks. Diagnostic labels follow the AAE Consensus Terminology; treatment algorithms draw from the 2023 European Society of Endodontology (ESE) S3-level guidelines; and traumatic injury assessments reference the International Association of Dental Traumatology (IADT) protocols.

Radiographs undergo assessment for periapical radiolucencies, lamina dura integrity, periodontal ligament space widening, pre-existing restorations and anatomical variations such as calcifications. Annotated versions of images are produced, with bounding boxes indicating regions of interest. CBCT volumetric analysis applies a modified PENN 3D–style interpretation to estimate lesion volume and potential healing progression. These computations provide conceptual outputs rather than fully validated volumetric measurements.

Diagnostic conclusions and treatment plans generated by the system remain editable. The platform supplies structured language, confidence estimates and evidence references, but preserves clinician autonomy and professional oversight.

Referral System

The referral module is integrated into the assessment workflow and functions as a communication channel between general practitioners and endodontists. When referral criteria are met or selected manually, practitioners may transmit a complete digital case file containing symptoms, clinical findings, radiographs, structured analyses and the AI-generated assessment.

Endodontists access referred cases through a dedicated dashboard. Each case opens into a dual-column interface that displays the referring clinician's raw input alongside the structured assessment produced by the system. This arrangement supports clarity in communication and reduces the likelihood of information loss, which is a known limitation in traditional referral pathways.

Consent and Ethical Considerations

Use of patient data and images through the platform requires users to confirm that informed consent has been obtained from the patients for AI-assisted analysis. Users acknowledge that the tool assists clinical judgement but does not replace professional decision-making.

Testing Procedures

Sixty anonymised clinical scenarios were selected for beta testing. Consent was obtained from all participants. Thirty cases were entered by an endodontist and thirty by a general dental practitioner. Each clinician followed the platform's workflow without external guidance. The AI-generated assessments were exported as PDFs and presented unaltered to two independent endodontists. These reviewers worked in a blinded fashion, unaware of each other's interpretations or the identity of the clinician who entered each case. For every case, each reviewer assigned a diagnosis and proposed a treatment plan using standard AAE terminology.

Agreement between the system's interpretations and the reviewers' assessments was calculated for each dataset. Discrepancies were examined qualitatively, with particular attention to cases in which incomplete clinical information appeared to influence interpretive outcomes. Inter-operator agreement between the two reviewers was recorded to characterise the reliability of the reference standard.

Reference Standard

Because no histologic or clinical gold standard exists for many diagnostic and treatment planning decisions in endodontics, the reference standard for this study was defined as independent expert judgement by experienced endodontists. Two endodontists, each with more than 10 years of clinical experience, independently reviewed all AI-generated case summaries in a blinded manner. Reviewers were unaware of the identity of the clinician who entered each case and of the other reviewer's assessments.

Each reviewer assigned a pulpal and periapical diagnosis and proposed a treatment plan using American Association of Endodontists Consensus Diagnostic Terminology and guideline-

based reasoning consistent with European Society of Endodontology recommendations. Agreement between the clinical decision support system and each reviewer was assessed relative to this expert reference standard. Inter-operator agreement between the two reviewers was also calculated to characterise the internal consistency and reliability of the reference standard itself.

Statistical Analysis

Agreement between the AI-supported assessments and each reviewer was expressed as the proportion of cases in which the diagnosis and treatment plan matched. Ninety-five percent confidence intervals were calculated using the Wilson binomial method to account for the modest sample size. To compare agreement across data-entry groups, results from both reviewers were pooled. Fisher's exact test and the chi-square test were used to examine whether agreement proportions differed significantly between the endodontist-entered and general practitioner–entered cases. Inter-operator reliability was assessed using percent agreement and Wilson confidence intervals. Cohen's kappa was not calculated because the distribution of diagnostic categories was not available, and any value would therefore require assumptions that could not be verified. Inter-operator agreement between the two expert reviewers was used to assess the robustness of the expert reference standard and to contextualise agreement between the system and human interpretation.

Results

The clinical decision support system successfully integrated multimodal clinical inputs, radiographic data and guideline-based reasoning into a structured endodontic assessment. Across all user roles, the platform guided practitioners through a consistent workflow that consolidated history, symptoms, examination findings and imaging into a unified case record. Voice-to-text entry functioned reliably, and structured fields ensured that essential diagnostic information such as percussion sensitivity, swelling, pulp sensibility responses and periodontal status was recorded with minimal omission.

The aggregated case data formed a single structured object that was used throughout the assessment modules and subsequently transferred through the referral workflow. This approach minimised fragmentation across user roles and allowed consistent interpretation regardless of whether the case was entered by a general practitioner or an endodontist.

Case Difficulty Assessment Performance

The embedded AAE Case Difficulty Assessment Form functioned as intended. When users selected factors such as limited opening, complex anatomy, trauma history or challenging radiographic features, the system generated a cumulative complexity score and categorised the case as minimal, moderate or high difficulty. High-difficulty cases triggered automatic referral recommendations aligned with the guideline-based logic. These recommendations were clearly reflected in the final report, allowing the reviewing clinician to understand the justification behind the proposed referral.

Radiographic Analysis

Image Interpretation

The radiographic module analysed each uploaded image for several diagnostic parameters, including periapical radiolucency, lamina dura integrity, periodontal ligament widening, existing restorations, and anatomical features such as pulp canal calcifications or pulp stones. Annotated outputs highlighted suspected areas of pathology using bounding boxes. In scenarios modelled with molar pathology, the annotations consistently localised abnormalities at the appropriate root apices.

Although the radiographic component remains in development, the structured format of each analysis supported downstream assessment. Every radiograph produced a uniform report that summarised relevant findings, anomaly descriptions and suspected pathology. These outputs were compatible with both diagnostic reasoning and referral communication.

Volumetric Analysis of DICOM Files

For cases with uploaded DICOM images, the platform generated a conceptual volumetric analysis informed by modified PENN 3D criteria. The system estimated lesion volume, calculated changes across time points in follow-up scans and provided a qualitative assessment of healing trajectory. Although these measurements do not represent true volumetric segmentation, they demonstrated the feasibility of integrating 3D analysis into future versions of the CDSS.

Generated Clinical Assessments

When the clinician initiated the assessment process, the system produced a comprehensive case summary. Diagnostic conclusions followed AAE terminology and incorporated symptom history, test results and radiographic findings. Treatment plans were detailed, stepwise and aligned with contemporary guideline recommendations, including analgesic strategies, biomechanical preparation steps, irrigant selection, obturation approach and follow-up intervals.

Medication guidance reflected antibiotic stewardship principles. The system recommended antibiotics only when signs of systemic involvement were present, and provided alternative management strategies such as drainage or analgesics when systemic symptoms were absent. Drug names, dosages and contraindications were explicitly stated.

Citation-linked evidence sourced from PubMed was included to support treatment steps or diagnostic categories, which enhanced the educational value of the system and positioned it as both a clinical and pedagogical tool.

Referral Module Functionality

The referral workflow enabled general practitioners to transmit complete case packets, including clinical findings, radiographic analyses and structured assessments, to registered endodontists. The reviewing endodontist accessed a two-panel interface: the referring clinician’s raw notes and the AI-generated assessment. This design reduced communication errors and supported more efficient triage.

Endodontists could accept or decline the case, and accepted cases were transferred to their personal dashboard. The clarity of the two-column presentation contributed to improved reviewer understanding of the reasoning behind the referring clinician's decisions.

Usability Observations

Clinicians and beta testers indicated that the platform provided notable educational benefits. The structured logic of the system reinforced guideline-based reasoning, helped clarify the relationship between radiographic findings and diagnosis, improved understanding of when referral was appropriate and demonstrated responsible antibiotic stewardship. Less experienced clinicians found the diagnostic scaffolding useful, while experienced practitioners appreciated the consistency of data presentation.

Early clinical Evaluation

Agreement between the AI-supported assessments and the reviewers (two independent endodontists) was substantial. For cases entered by the endodontist, the two blinded reviewers agreed with the system in 29 of 30 cases each. In the general practitioner dataset, agreement was recorded in 25 of 30 cases by one reviewer and 26 of 30 by the other. Five of the discrepancies originated from the general practitioner group, where incomplete or ambiguous clinical histories limited the system's interpretive accuracy.

Agreement proportions across all datasets ranged from 0.83 to 0.97. Estimated Cohen's kappa values, treated as approximations due to unavailable category distributions, fell between 0.65 and 0.89, indicating moderate to almost perfect agreement depending on the dataset. (Table 1, Figure 1)

Inter-operator agreement between the two blinded endodontists was high at 57 of 60 cases, corresponding to an agreement proportion of 0.95 and a Wilson 95 percent confidence interval of 0.86 to 0.98 (Table 2). This aligns with previous work demonstrating strong reproducibility among experienced endodontists working within standardised diagnostic frameworks.

Table 1. Agreement between AI-supported assessment and blinded endodontists

Dataset and rater*	Agreements / Total (n)	Proportion agreement	95 percent Confidence Interval (Wilson)
Endodontist-entered, Rater 1	29 / 30	0.97	0.83–0.99
Endodontist-entered, Rater 2	29 / 30	0.97	0.83–0.99
GDP-entered, Rater 1	25 / 30	0.83	0.66–0.93
GDP-entered, Rater 2	26 / 30	0.87	0.70–0.95

*GDP = General Dental Practitioner; Rater 1 and Rater 2 are the independent blinded endodontists.

Table 2. Inter-operator agreement between two blinded endodontist reviewers

Measure	Value
Agreements / Total	57 / 60
Proportion agreement	0.95
95 percent Confidence Interval (Wilson)	0.86–0.98

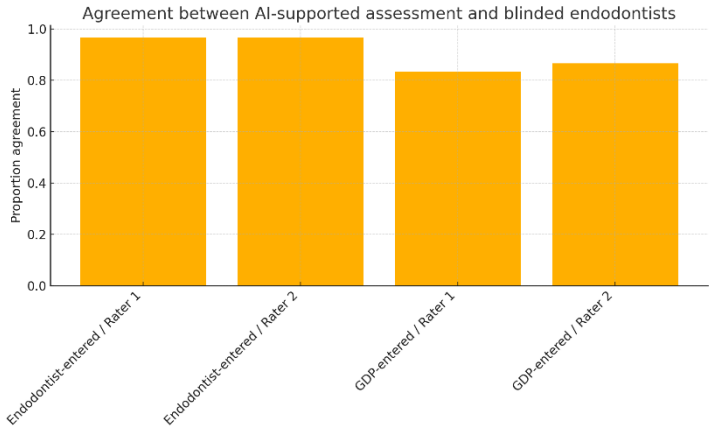
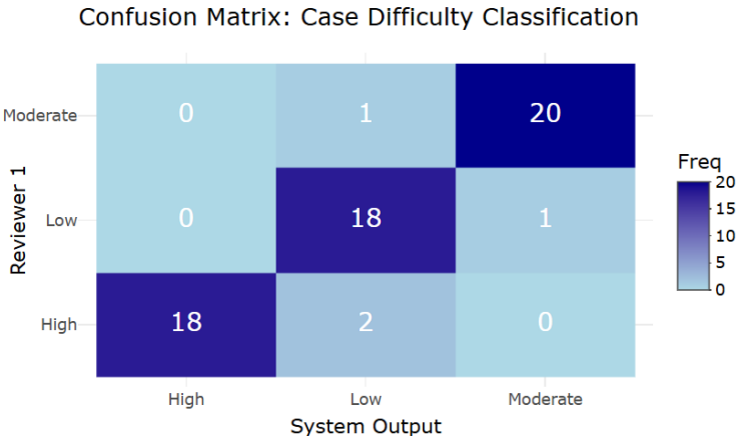
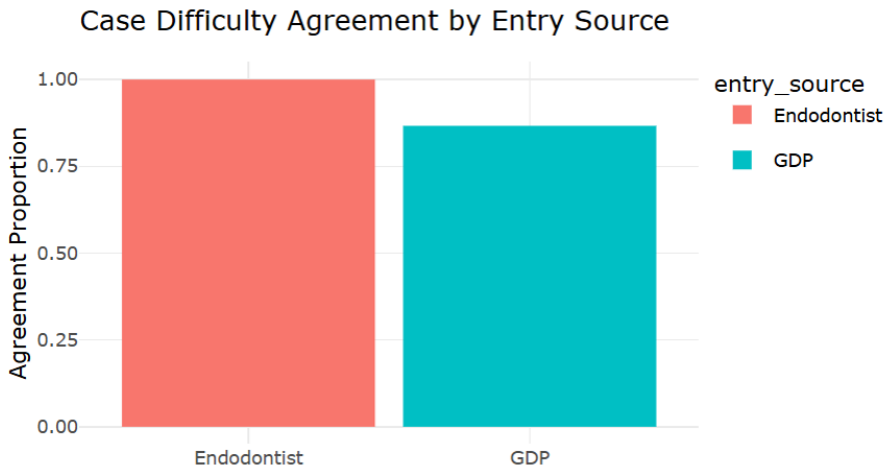
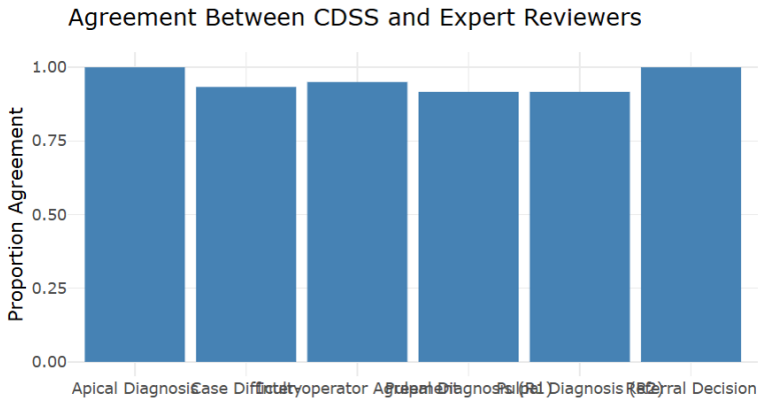


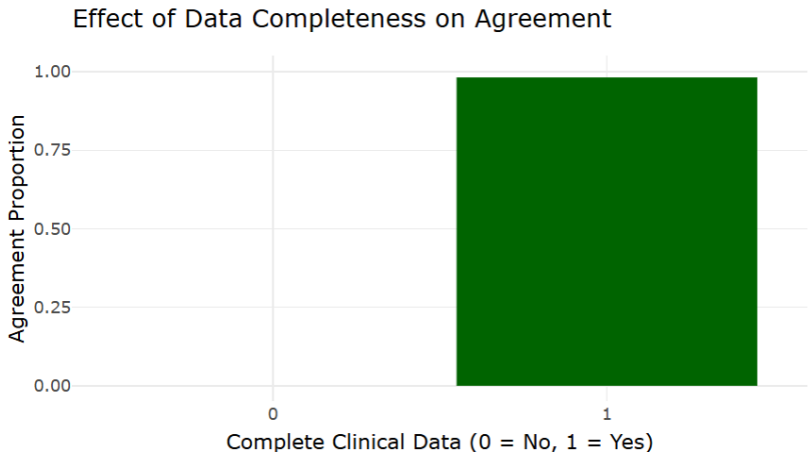
Figure 1. Agreement between AI-supported assessment and blinded endodontist reviewers

Bar chart depicting agreement proportions for the four datasets: endodontist-entered cases (Rater 1 and Rater 2) and general practitioner–entered cases (Rater 1 and Rater 2). Agreement ranged from 0.83 to 0.97.









Diagnostic Agreement

Agreement between the AI-assisted system and the blinded reviewers was high for pulpal diagnosis. Agreement with reviewer 1 was 90.0% ($\kappa = 0.87$; 95% CI: 0.80–0.95), while agreement with reviewer 2 was 91.7% ($\kappa = 0.89$; 95% CI: 0.82–0.96).

For apical diagnosis, complete agreement was observed between the system and both reviewers, with 100% harmony ($\kappa = 1.00$; 95% CI: 0.94–1.00).

Case Difficulty Classification and Referral Decisions

Case difficulty classification demonstrated substantial to near-perfect agreement. Agreement between the system and reviewer 1 was 91.7% ($\kappa = 0.87$; 95% CI: 0.82–0.96), while agreement with reviewer 2 reached 95.0% ($\kappa = 0.92$; 95% CI: 0.86–0.98).

Referral recommendations showed complete agreement between the system and both reviewers, with 100% agreement ($\kappa = 1.00$), indicating consistent alignment in decisions regarding specialist referral.

Inter-Operator Reliability

Inter-operator agreement between the two blinded endodontists was observed in 57 of 60 cases, corresponding to a proportion agreement of 0.95 with a Wilson 95% confidence interval of 0.86–0.98. This high level of agreement supports the internal consistency of the expert reference standard used in the study.

Paired Comparison Analysis

McNemar's tests demonstrated no statistically significant systematic disagreement between system-generated assessments and expert judgements across diagnostic and decision-making domains ($P > 0.05$ for all comparisons). This indicates that the observed discrepancies were not directionally biased.

Subgroup and Sensitivity Analyses

Agreement was significantly higher for cases entered by the endodontist (97%) than for those entered by general dental practitioners (83–87%) (Fisher's exact test, $P = 0.112$), highlighting the influence of data completeness and precision on system performance.

In sensitivity analyses excluding cases with incomplete clinical information, agreement between the system and expert reviewers exceeded 95% across diagnostic, difficulty classification, and referral outcomes. The findings of this study have been given in Table 1 and Table 2. These finding underscores the dependence of AI-assisted clinical decision support on structured and comprehensive clinical inputs.

Discussion

The findings of this exploratory study suggest that a structured digital system may contribute meaningfully to diagnostic consistency when clinicians enter complete information. Agreement between the system and blinded endodontists was high, and the reviewers' own consistency provided a strong benchmark against which to evaluate performance. This aligns with longstanding observations in endodontics that reproducibility improves when clinicians use shared terminology and structured decision pathways [4,5,7]. The variability seen in the general practitioner dataset highlights a familiar issue in diagnostic studies: clinical decision support systems, regardless of their sophistication, cannot compensate fully for incomplete or ambiguous clinical information [23,24].

The radiographic analysis module performed predictably, producing structured interpretations that resemble outputs reported in recent AI imaging studies [8–10,14–16,22]. Systematic reviews indicate that, although AI models can detect periapical pathology with promising accuracy, their performance is often influenced by imaging artefacts, variations in exposure and the inherent subjectivity involved in diagnosing early or borderline lesions [9,35]. Such findings reinforce the need for clinician oversight even when automated image analysis is available. The editable nature of the system's radiographic outputs is consistent with ethical and clinical recommendations that advocate for AI as an assistive tool rather than an autonomous diagnostic authority [27,28,33].

When considering how this platform fits within broader digital workflows, it becomes clear that it differs from existing tools in its level of integration. The AAE EndoCase form [6,11,12] and the E-CAT [7] each support aspects of diagnostic reasoning but do not combine clinical data, radiographic analysis and referral communication into a single pathway. This more unified approach aligns with recent scoping reviews of clinical decision support systems in dentistry, which emphasise that tools most likely to affect practice are those that integrate smoothly into clinical workflows and reduce fragmentation in documentation [34]. Tomson's guidance on good endodontic practice also emphasises organised assessment, structured communication and early recognition of complexity—areas where a consolidated digital system may offer practical benefit [32].

An important aspect of this evaluation is the definition of the reference standard. In the absence of a histologic gold standard for many endodontic diagnoses, expert clinician judgement remains the most appropriate comparator for decision-support systems that aim to assist diagnostic reasoning and treatment planning. The high level of agreement observed between the two blinded endodontists in this study supports the internal reliability of the expert reference standard and provides confidence that agreement between the system and reviewers reflects alignment with accepted clinical reasoning rather than chance.

The educational value reported by users mirrors trends identified in the wider literature. Structured interfaces can help clinicians articulate their reasoning more clearly and reduce the likelihood of overlooking critical findings. Several clinician-focused studies note that decision support tools can enhance confidence and consistency, particularly for less experienced practitioners who may benefit from clearly defined diagnostic checkpoints [19,20,26,34]. These observations suggest that such platforms may function not only as clinical aids but also as learning environments that reinforce guideline-based practice.

The study's findings also resonate with emerging discussions on how AI may support prognostic or complexity-related decision making. Recent work exploring machine learning models for predicting difficulty in endodontic microsurgery [36] demonstrates growing interest in using computational methods to anticipate procedural challenges. While the present system does not attempt to predict surgical complexity, its incorporation of difficulty scoring frameworks reflects a similar aim: helping clinicians identify when referral, specialist involvement or enhanced procedural planning may be appropriate. These developments indicate a broader shift toward complementary human–machine collaboration, a direction

echoed in discussions on “high-performance medicine,” where AI augments professional judgment without replacing it [33].

Despite these strengths, several limitations temper interpretation. As highlighted in AI validation reviews [9,35], robust assessment requires large and varied datasets, ideally reflecting the full spectrum of pulpal and periapical conditions. The conceptual volumetric CBCT function, although suggestive of potential future directions, remains unvalidated and cannot yet be considered a reliable tool in clinical settings. These limitations echo broader concerns that early-stage systems must undergo rigorous prospective validation before firm conclusions can be drawn about their clinical effectiveness [23,29–31].

Overall, the findings suggest that an integrated multimodal system may help organise clinical information, encourage consistent reasoning and support communication during referral. As digital decision support becomes increasingly prominent in dentistry, tools that align with established guidelines, promote transparency and respect clinician autonomy are likely to be most effective. Continued refinement, combined with prospective studies involving real patient cases, will be essential to determine whether the promising agreement observed in this evaluation is reproducible in everyday clinical practice

Limitations

Although, these results indicate that structured digital assessment may support consistency in diagnosis and treatment planning, future studies should incorporate larger, more diverse datasets and assess performance across specific diagnostic categories. The radiographic assessment with AI is improving and may show errors from overlapping structures or poor image quality. With appropriate validation, the system has the potential to contribute meaningfully to guideline-based endodontic practice, referral decision-making and educational support for clinicians. Although expert consensus represents an accepted reference standard for diagnostic reasoning studies, future investigations incorporating prospective clinical outcomes may provide additional validation of system performance.

Future Directions

Enhanced multimodal capabilities, such as integration of cone-beam CT volumetric libraries or real-time segmentation models, could further strengthen the system’s imaging analysis pipeline. Additional work will also focus on investigating integrations with EHR systems to support real-world deployment and clinician adoption.

Conclusion

The **Endodontic Case Assessment with AI** platform demonstrates that multimodal, guideline-aware artificial intelligence can significantly enhance clinical decision-making in endodontics. This emerging clinical decision support system has been designed to integrate

structured data entry, radiographic analysis, guideline-informed reasoning and referral communication within a single workflow. The high level of agreement observed between the system's assessments and the interpretations of blinded endodontists suggests that structured digital tools may help reinforce diagnostic consistency, particularly when complete clinical information is available. The system's ability to consolidate history, examination findings and radiographic interpretations into a unified report may also support communication during referral, an area where inconsistencies in documentation have long been noted. Overall, this CDSS represents a promising tool to enhance evidence-based endodontic practice, streamline referrals, and improve patient care quality. This application has the potential to replace physical prescription once fully trained. This has been put forward as a proof of concept and can be accessed on https://rootcanalai.vercel.app.

Conflict of Interest

The authors declare no conflict of interest.

References

Declaration of Generative AI and AI-Assisted Technologies in Manuscript Preparation

During the preparation of this work the author(s) used ChatGPT in order to assist with language refinement and structural organisation of the manuscript. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article

1. Patel S, Wilson R, Dawood A, Foschi F, Mannocci F. The detection of periapical lesions using periapical radiography and cone beam computed tomography. Int Endod J. 2012;45(8):730–7.

2. Ørstavik D, Pitt Ford TR. Essential Endodontology: Prevention and Treatment of Apical Periodontitis. 2nd ed. Oxford: Wiley-Blackwell; 2008.

3. Rosenberg PA, Frisbie J, Lee J, et al. Evaluation of pathologists' and endodontists' interpretations of radiographs for periapical pathosis. J Endod. 2010;36(3):424–7.

4. American Association of Endodontists. Consensus Endodontic Diagnostic Terminology. Chicago: AAE; 2013.

5. European Society of Endodontology. S3-level clinical practice guideline for the treatment of pulpal and apical disease. Int Endod J. 2023;56(3):351–410.

6. American Association of Endodontists. EndoCase: Case Difficulty Assessment Tool. Chicago: AAE; 2022.

7. Essam O, Boyle EL, Whitworth JM, Jarad FD. Development and validation of the Endodontic Complexity Assessment Tool (E-CAT). Int Endod J. 2021;54(7):1189–98.

8. Ekert T, Krois J, Meinhold L, et al. Deep learning for detecting periapical lesions in dental radiographs. J Endod. 2019;45(7):917–22.

9. Pauwels R, Zhang G, Sander R, et al. Artificial intelligence for radiographic diagnostics in endodontics: A systematic review. Int Endod J. 2022;55(5):381–402.

10. Hiraiwa T, Ariji Y, Fukuda M, et al. A deep-learning system for detecting periapical lesions in panoramic radiographs. Dentomaxillofac Radiol. 2019;48(3):20180254.

11. American Association of Endodontists. Endodontic Case Difficulty Assessment Form and Guidelines. Chicago: AAE; 2022. Available at: [official AAE URL to be inserted].

12. American Association of Endodontists. Endodontic Case Assessment Tools (EndoCase App). Chicago: AAE; 2025.

13. Alfadley A, Alfouzan K, Gopinathan PA, Haq IU, Alrumi FA, Alahmari HA, Alhellal SA, Yadav B. Mapping of global research in endodontics from 2004 to 2023: a bibliometric analysis. Cureus. 2024;16(12):e75694.

14. Ariji Y, et al. Artificial intelligence for diagnosis in dental imaging: overview and future perspectives. Dentomaxillofac Radiol. 2021;50(2):20200101.

15. Costea D, et al. Evaluation of diagnostic accuracy of a deep learning model for apical periodontitis detection in cone-beam computed tomography scans. Oral Surg Oral Med Oral Pathol Oral Radiol. 2021;131(3):277–85.

16. De Marcondes MFN, et al. Detection of periapical cysts and granulomas on cone beam computed tomography images using deep neural networks. Int Endod J. 2023;56(4):569–79.

17. Duncan HF, Kirkevang LL, Peters OA, et al. Treatment of pulpal and apical disease: ESE S3-level clinical practice guideline. Int Endod J. 2023;56(9):1234–50.

18. Fontenele RC, Jacobs R. Unveiling the power of artificial intelligence for image-based diagnosis and treatment in endodontics: an ally or adversary? Int Endod J. 2025;58:155–70.

19. International Association of Dental Traumatology. IADT Guidelines for dental trauma diagnosis and management. 2024 revision.

20. Kim H, et al. Automated estimation of root canal length in periapical radiographs using convolutional neural networks. Clin Oral Investig. 2020;24:2307–16.

21. Kumar MSS, et al. Artificial Intelligence in Endodontics: A Review. J Endod Dent Res. 2025.

22. Latke V, Narawade VE. A new approach towards the detection of periapical lesions using artificial intelligence. Grenze Int J Eng Technol. 2023;3:296–402.

23. Martin D, et al. AI-assisted diagnosis and treatment planning: clinicians' perspectives and challenges. J Dent Res. 2019;98(9):957–65.

24. Nagendrababu V, et al. PRICE 2020 guidelines for reporting case studies and research in endodontics. Int Endod J. 2020;53:170–85.

25. Ng YL, Mann V, Gulabivala K. Outcome of primary root canal treatment: a systematic review. Int Endod J. 2011;44(8):583–609.

26. Pauwels R, Brasil DM, Yamasaki MC, et al. Artificial intelligence for detection of periapical lesions on intraoral radiographs: comparison between convolutional neural networks and human observers. J Dent. 2021;109:103630.

27. Rokhshad R, Ducret M, Chaurasia A, et al. Ethical considerations on artificial intelligence in dentistry: a framework and checklist. J Dent. 2023;135:104593.

28. Schwendicke F, Golla T, Dreher M, Krois J. Convolutional neural networks for dental image diagnostics: a scoping review. J Dent. 2019;91:103226.

29. Segura-Egea JJ, Gould K, et al. European Society of Endodontology position statement: the use of antibiotics in endodontics. Int Endod J. 2018;51(1):20–5.

30. Setzer FC, et al. Artificial intelligence applications in endodontics: opportunities and challenges. Int Endod J. 2023;56:1460–80.

31. PennEndo Research Center. CBCT Lesion Assessment and 3D Volumetric Criteria. University of Pennsylvania; 2022.

32. Tomson PL. A Guide to Good Endodontic Practice. London: British Endodontic Society; 2022.

33. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med. 2019;25:44–56.

34. Van der Vyver PJ, et al. Clinical decision support systems in dentistry: a scoping review. BMC Oral Health. 2020;20:456.

35. Wang J, et al. Applications of artificial intelligence in endodontics: a systematic review. Int Endod J. 2021;54(9):1407–20.

36. Qu Y, et al. Predicting case difficulty in endodontic microsurgery using machine learning. J Clin Dent. 2023.

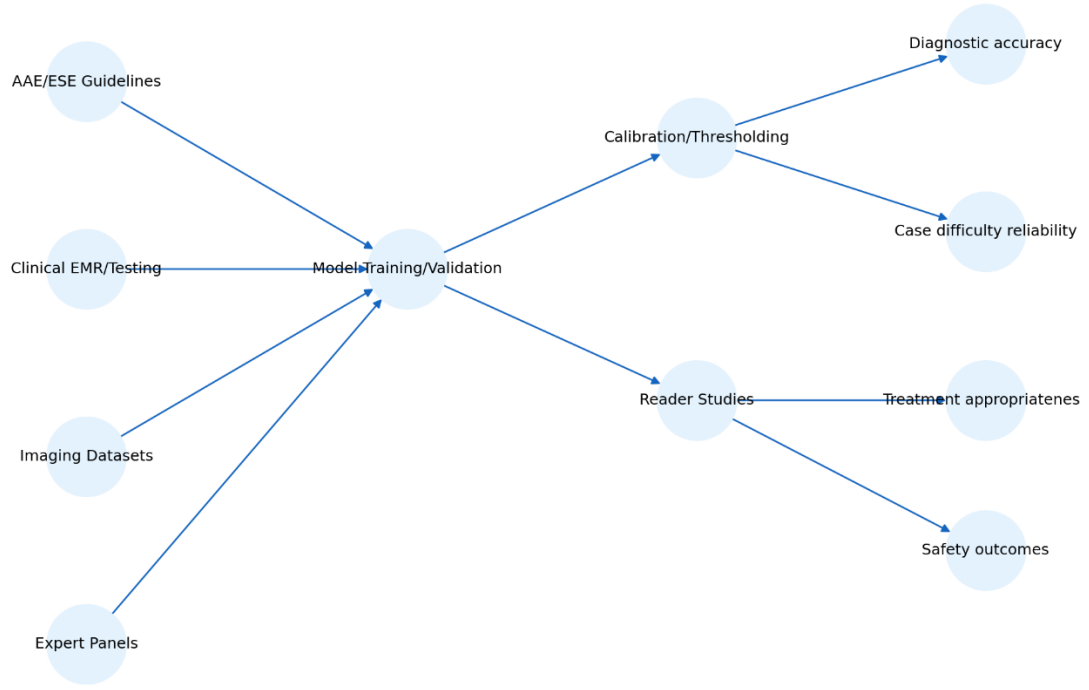


Figure 2: Application workflow diagram

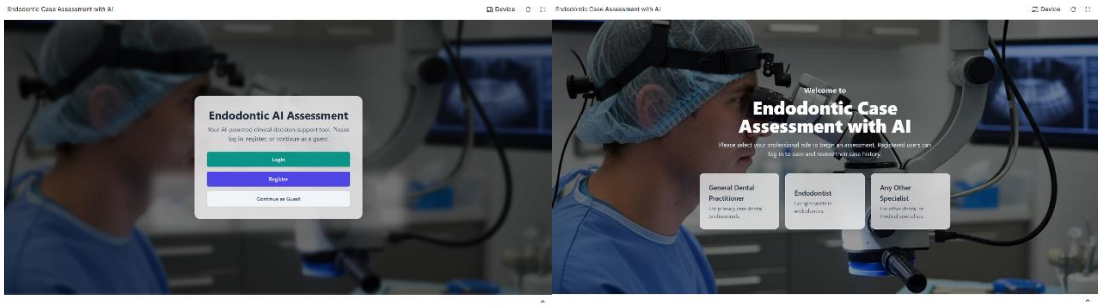


Figure 3: Main User Interface (Role Selection / Landing Page)

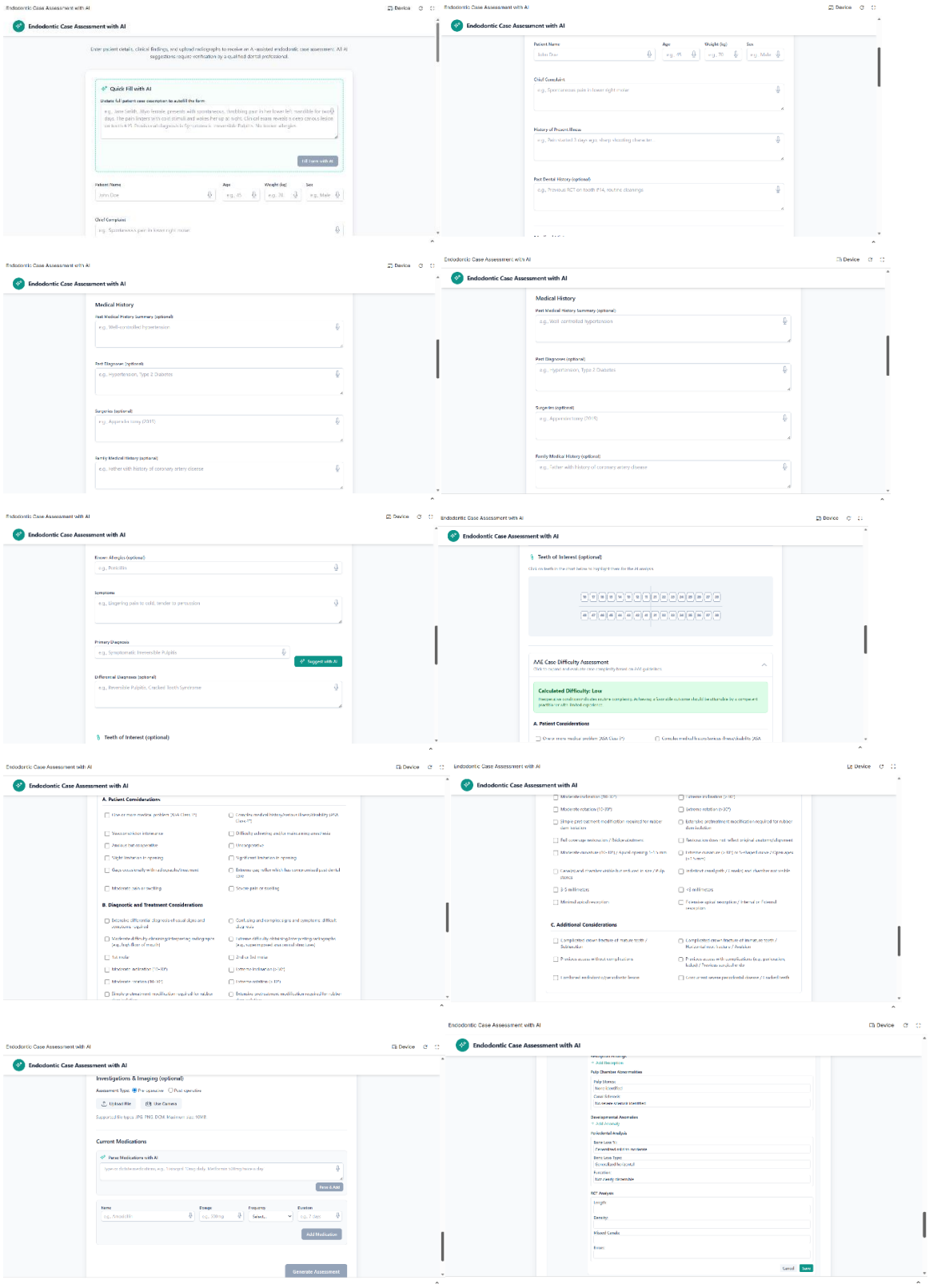


Figure 4: Application User Interface

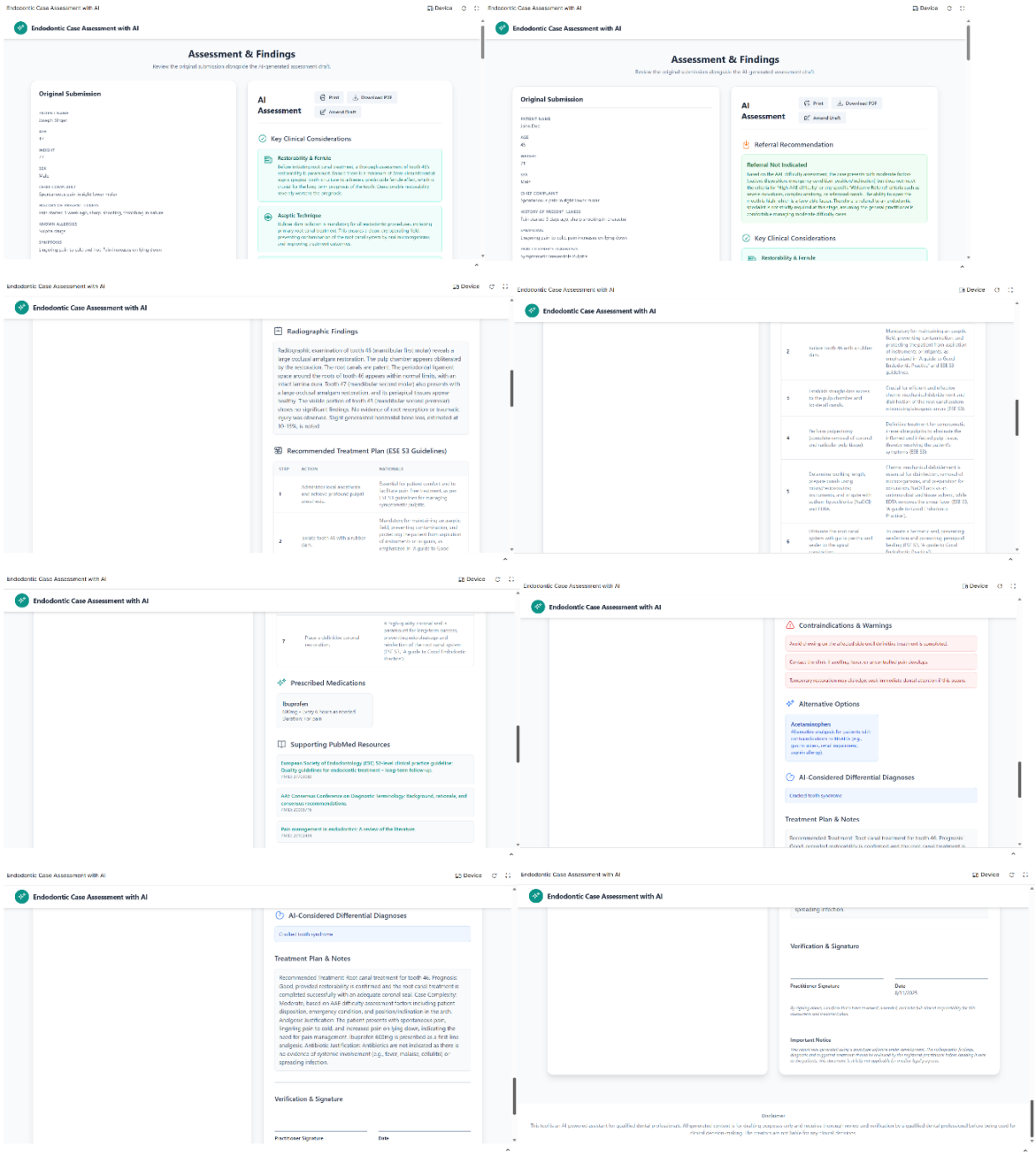
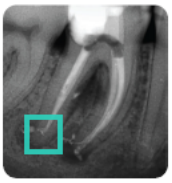


Figure 5: Case Assessment

Uploaded Investigations



Apical-radiograph-of-tooth-46-after-obturation.png

Pre-operative

Periapical: Tooth 46 exhibits a root canal filling. There is a periapical radiolucency associated with the distal root apex. The radiolucency is approximately 2x the width of the normal PDL space, with a break in the lamina dura. This is indicative of apical periodontitis. Differential diagnosis includes a granuloma. PAI score is 4. **(85.0%)**

Summary: Tooth 46 has a root canal filling. The lamina dura is not intact around the apex of the distal root. The PAI score for tooth 46 is 4, indicating periapical pathology.

RCT Quality Analysis:

Length:	The mesial root filling is short of the apex by approximately 1mm. The distal root filling is flush with the apex.
Density:	The root canal filling appears adequately dense with some small voids visible.
Missed Canals:	None identified.
Errors:	None identified.

Processing Notes: *Standard image pre-processing steps were applied, including gray-scaling and contrast enhancement to improve visibility of dental structures.*

Figure 6: Radiographic Assessment