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Assessing Diagnostic Accuracy: AI-Assisted Versus Manual Interpretation of Digital Dental Radiographs

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KEYWORDS

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ABSTRACT:

Aim: to evaluate the effectiveness and diagnostic precision of manual versus AI-assisted digital dental radiograph interpretation.

Methodology: AI-based software and seasoned radiologists examined two hundred radiographs, including bitewing, panoramic, and periapical pictures. Evaluations were conducted on interobserver agreement, sensitivity, specificity, predictive values, and interpretation time.

Results: AI-assisted interpretation showed higher sensitivity (94.2%) and specificity (92.5%) than manual reading (89.6% and 90.3%) and reduced mean interpretation time (21.4 vs 48.7 seconds). Agreement with reference standard was higher for AI (kappa = 0.87).

Conclusion: AI-assisted radiographic interpretation is a dependable adjunct in dentistry that improves diagnostic accuracy and cuts down on reading time.

Background

For the diagnosis and treatment of a variety of oral pathologies, such as dental caries, periapical lesions, periodontal bone loss, and implant evaluation, digital dental radiographs are an essential tool in contemporary dentistry [1]. For efficient clinical decision-making and treatment planning, these radiographs must be interpreted accurately. Despite its dependability, radiographic analysis has historically relied on manual interpretation by qualified dental radiologists or clinicians, which can be time-consuming and subject to interobserver variability [2]. Recent developments in deep learning algorithms and artificial intelligence (AI) have opened up new avenues for improving dental radiology's diagnostic efficiency and accuracy [3]. AI-assisted systems have the potential to improve early diagnosis of caries and periapical lesions by detecting subtle radiographic changes that the human eye might miss [4]. Additionally, these systems can standardise assessments, decrease clinician variability, and offer quick evaluations—all of which are particularly helpful in clinical settings with high patient volumes [5]. The increasing use of AI in dental radiography has been noted in a number of studies. In identifying dental caries on intraoral radiographs, randomised controlled trials have shown that AI-based software can perform diagnostically on par with or even better than skilled radiologists [1]. AI has also been demonstrated to help postgraduate students measure working length on periapical radiographs accurately, suggesting that it can be used in both clinical and educational settings [2]. A variety of dental pathologies can be detected with AI-based panoramic radiograph evaluation, which has demonstrated high concordance with human reference standards [3]. Despite these encouraging advancements, issues with clinical validation, interpretability, and reliability continue to hinder the widespread adoption of AI in daily practice [6]. Additionally, more research is needed to determine the relative benefits of AI-assisted versus conventional manual interpretation in terms of interobserver agreement, time efficiency, and diagnostic accuracy [7]. Comprehending these facets is crucial for streamlining dental radiology workflows, guaranteeing patient security, and directing upcoming studies on AI application. With the potential to improve accuracy, decrease workload, and standardise assessments across various clinical contexts, the use of AI-assisted radiographic interpretation represents a substantial advancement in dental diagnostics overall.

Methodology

Between January 2025 and June 2025, a tertiary dental care center's Department of Oral Radiology hosted this observational, cross-sectional study. Patients who needed routine digital dental radiographs, such as bitewing, panoramic, and intraoral periapical images, were included in the study population. Patients between the ages of 18 and 65 who had a fully erupted permanent dentition and no history of extensive restorative procedures or orthodontic appliances that might have obstructed radiographic interpretation were eligible to participate. Patients with poor-quality radiographs or systemic conditions affecting dental structures were not included. Two hundred radiographs in all were chosen at random and anonymised for analysis. A manual interpretation group comprising three seasoned dental radiologists and an AI-assisted interpretation group using a validated deep learning program trained for dental caries, periapical lesions, periodontal bone loss, and implant detection independently examined each radiograph. The location, severity, and number of lesions were among the standard diagnostic criteria that radiologists used to record findings. The diagnostic outputs produced by the AI software were automatically compared to human evaluations. Senior radiologists agreed to create a reference standard in order to resolve differences between AI and human interpretations. Diagnostic accuracy, as measured by sensitivity, specificity, positive predictive value, and negative predictive value for identifying dental pathologies, was the main outcome measure. Concordance between AI and human interpretations, interpretation time, and interobserver agreement among radiologists were secondary outcomes. SPSS version 26.0 was used to conduct the statistical analysis. Radiographic and demographic variables were analysed using descriptive statistics. Paired t-tests and receiver operating

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characteristic (ROC) curve analysis were used to examine the differences in diagnostic performance between AI and manual interpretation; a p-value of less than 0.05 was deemed statistically significant. The efficiency and diagnostic reliability of AI-assisted versus manual radiographic interpretation in identifying common dental pathologies can be objectively compared in a clinical setting thanks to this methodology.

Results

In this study, 200 digital dental radiographs were examined, comprising 30 (15%) panoramic, 50 (25%) bitewing, and 120 (60%) intraoral periapical images. With 112 males (56%) and 88 females (44%), the study population's mean age was 34.5 ± 10.2 years. In order to detect dental caries, periapical lesions, and periodontal bone loss, radiographs were evaluated independently by skilled dental radiologists and a validated AI-assisted program. When compared to manual evaluation, AI-assisted interpretation showed better diagnostic performance overall. AI had a 94.2% sensitivity and 92.5% specificity in identifying all evaluated dental pathologies, compared to 89.6% sensitivity and 90.3% specificity for manual interpretation. Additionally, AI's positive predictive value (PPV) and negative predictive value (NPV) were higher (91.8% and 94.7%, respectively) than manual readings' (88.7% and 90.8%, respectively). The efficiency of AI-assisted analysis was significantly improved, as evidenced by the significantly lower mean interpretation time per radiograph (21.4 ± 4.3 seconds) compared to manual assessment (48.7 ± 6.8 seconds). While the concordance between AI output and the reference standard was higher (kappa = 0.87), indicating excellent reliability, the interobserver agreement among radiologists for manual interpretation was significant (Cohen's kappa = 0.78). In cases where manual interpretation occasionally missed minor or less distinct pathologies, AI performance was especially noteworthy in detecting early-stage carious lesions and subtle periapical changes. Both AI and manual interpretation produced results that were comparable for advanced caries and significant loss of periodontal bone. These results support AI's role as a useful adjunct in clinical dental radiology by indicating that it not only preserves diagnostic accuracy but also lowers reading time and interobserver variability (Table 1).

Table 1: Diagnostic Performance of AI-Assisted vs Manual Interpretation in Digital Dental Radiographs (n = 200)

Parameter	AI-Assisted Interpretation	Manual Interpretation
Sensitivity (%)	94.2	89.6
Specificity (%)	92.5	90.3
Positive Predictive Value (%)	91.8	88.7
Negative Predictive Value (%)	94.7	90.8
Mean Interpretation Time (seconds)	21.4 ± 4.3	48.7 ± 6.8
Cohen's Kappa (Agreement with Reference)	0.87	0.78

The results indicate that AI-assisted interpretation significantly improves diagnostic accuracy and reduces reading time, supporting its integration into routine dental radiology workflows.

Discussion

Recent studies have shown that AI-assisted dental radiograph interpretation offers high diagnostic accuracy for a range of dental diseases. Dental radiology workflow efficiency has been greatly increased by the successful

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application of semi-supervised learning techniques to panoramic radiographs, which allow for accurate tooth numbering, lesion segmentation, and precise dental condition detection [8]. These methods lessen reliance on large annotated datasets by enabling AI systems to use both labelled and unlabelled data. This is especially useful in real-world clinical settings where it may not be possible to obtain large volumes of labelled radiographs. In addition, methods for self-supervised learning have been created to improve model performance even more. By using these methods, AI models can more successfully generalise across a range of patient demographics and radiographic variances by learning reliable feature representations from unprocessed image data without the need for direct supervision [9]. Dental caries, periapical lesions, and periodontal bone loss are just a few of the diseases that can be detected with remarkable accuracy by deep learning models, especially those that are implemented using frameworks like TensorFlow and Keras. The reliability of AI algorithms as diagnostic adjuncts in routine practice has been reinforced by systematic reviews and meta-analyses, which have confirmed that these algorithms frequently achieve sensitivity and specificity comparable to, and occasionally surpass, that of skilled radiologists [11]. Furthermore, comparative research shows that AI-assisted interpretation can address one of the main drawbacks of traditional manual evaluation, where subjective variations among clinicians may impact diagnostic results, by lowering interobserver variability and enhancing consistency across readings [12]. The effectiveness of AI in segmenting various dental features on periapical and panoramic radiographs is further highlighted by clinical validation studies. It has been demonstrated that automated systems can precisely identify dental implants, restorations, and carious lesions, which helps with treatment planning and long-term dental health monitoring [13,14]. Convolutional neural networks (CNNs) and attention-based models are two examples of advanced deep learning techniques that enable AI to identify minute radiographic changes, especially in early-stage lesions that human observers might miss. These skills are essential for planning minimally invasive treatments and for early diagnosis [15]. AI applications can identify carious lesions with high sensitivity and specificity, according to recent validation studies on intraoral bitewing and periapical radiographs [16]. This further supports the integration of AI applications into standard clinical workflows. Similar to this, AI-based dental implant detection and numbering on panoramic radiographs demonstrates how adaptable these systems are for intricate diagnostic tasks like implant planning and post-operative evaluation [20]. AI-assisted radiographic analysis for identifying restorations and other dental anomalies can now be used in clinics with little computational know-how thanks to the development of no-code computer vision platforms [21]. Adding AI to dental radiology workflows improves operational effectiveness as well. In contrast to manual reading, which is frequently time-consuming, AI models offer analysis that is almost instantaneous, according to several studies that report shorter interpretation times without sacrificing diagnostic accuracy [22]. This effectiveness lowers diagnostic errors brought on by fatigue, increases throughput in busy clinics, and frees up clinicians to concentrate on patient care. Additionally, AI can help to minimise subjective bias, standardise diagnostic procedures, and ensure consistent quality across various operators and institutions. Even with these encouraging developments, a number of obstacles still exist. The quality of radiographs, differences in imaging equipment, and the small variety of training datasets can all have an impact on AI performance, which may have an impact on

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generalisability across various clinical settings and demographics [8–22]. Furthermore, professional clinical supervision is still necessary for some complex cases, such as uncommon pathologies or atypical anatomical variations. This emphasises that rather than taking the place of human expertise, AI should be used as a supplementary tool [9,12]. For accuracy, dependability, and clinical robustness, future research should concentrate on multi-center validation studies, integrating AI outputs with electronic health records, and continuously improving algorithms. In summary, when compared to manual evaluation, AI-assisted interpretation of dental radiographs exhibits superior diagnostic accuracy, efficiency, and consistency. A major step forward in the development of digital dental radiology could be marked by its implementation in clinical practice, which could improve diagnostic confidence, lessen clinician workload, and standardise patient care.

Conclusion

When compared to manual reading, AI-assisted interpretation of digital dental radiographs greatly increases diagnostic efficiency and accuracy. Especially for early lesions, it exhibits greater sensitivity, specificity, and faster analysis time. AI integration can lower observer variability and improve clinical decision-making. All things considered, AI is a trustworthy supplement to standard dental radiology procedures.

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