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COMPARATIVE DIAGNOSTIC ACCURACY OF DIGITAL AND CONVENTIONAL RADIOGRAPHY IN THE DETECTION OF DENTAL CARIES

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Abstract
Accurate and early detection of dental caries is essential for effective treatment planning and prevention of disease progression. Radiographic examination remains a key diagnostic tool in clinical dentistry; however, the transition from conventional film-based radiography to digital imaging systems has raised questions regarding comparative diagnostic performance. This study evaluates the diagnostic accuracy of digital radiography in comparison with conventional radiographic methods for the detection of dental caries. A comparative clinical study was conducted involving patients undergoing routine dental examination. Both digital and conventional radiographic images were obtained under standardized conditions and independently evaluated for the presence and extent of carious lesions. Diagnostic performance was assessed using sensitivity, specificity, and overall accuracy metrics. The results demonstrated higher sensitivity and improved lesion detectability with digital radiography, particularly for early-stage and approximal caries, while specificity remained comparable between the two methods. These findings indicate that digital radiography offers enhanced diagnostic capabilities without compromising diagnostic reliability. The study supports the clinical use of digital radiographic systems as an effective and efficient tool for the early diagnosis of dental caries.

Keywords. Dental caries; Digital radiography; Conventional radiography; Diagnostic accuracy; Dental imaging.

Introduction

Dental caries remains one of the most prevalent chronic oral diseases worldwide, affecting individuals of all age groups and representing a significant public health concern. Early and accurate diagnosis is essential for preventing lesion progression, preserving tooth structure, and selecting minimally invasive treatment strategies. While visual and tactile clinical examination remains fundamental, radiographic assessment plays a critical role in detecting carious lesions that are not clinically visible, particularly approximal and early-stage lesions.

Conventional film-based radiography has long been considered the standard imaging modality in dental diagnostics. It provides valuable information on tooth structure and carious lesion depth; however, it is associated with several limitations, including image processing time, limited image enhancement options, and challenges in image storage and retrieval. These constraints have driven the rapid adoption of digital radiographic systems in modern dental practice.

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Digital radiography offers several potential advantages over conventional techniques, such as reduced radiation exposure, immediate image acquisition, enhanced image quality through contrast and brightness adjustments, and improved data management. These features suggest that digital systems may improve the detection of early carious changes and enhance diagnostic confidence. Nevertheless, concerns remain regarding image resolution, diagnostic consistency, and the potential for over- or under-diagnosis when compared with traditional film-based methods.

Previous studies comparing digital and conventional radiography have reported variable results, often influenced by differences in imaging systems, diagnostic criteria, observer experience, and study design. As a result, there is no universal consensus regarding the superiority of one method over the other in routine clinical practice, particularly for the detection of early and non-cavitated carious lesions.

Therefore, the present study aims to compare the diagnostic accuracy of digital and conventional radiographic techniques in the detection of dental caries under standardized clinical conditions. By evaluating sensitivity, specificity, and overall diagnostic performance, this research seeks to clarify the clinical value of digital radiography and support evidence-based decision-making in dental diagnostic imaging.

Materials and Methods

A comparative diagnostic study was conducted to evaluate the accuracy of digital and conventional radiographic methods in the detection of dental caries. The study population consisted of patients who attended routine dental examinations and required radiographic assessment as part of standard diagnostic procedures. Teeth with restorations, advanced structural damage, or previous endodontic treatment were excluded to avoid diagnostic bias.

Both digital and conventional bitewing radiographs were obtained for each participant under standardized exposure conditions. Conventional radiographs were acquired using film-based systems and processed according to manufacturer-recommended protocols. Digital radiographs were captured using an intraoral digital sensor with standardized exposure parameters to ensure comparability between imaging modalities.

Radiographic images were independently evaluated by experienced dental clinicians who were blinded to clinical findings and to each other's assessments. Carious lesions were classified according to lesion depth and location, with particular attention to early and approximal caries. To reduce observer-related variability, all evaluators underwent calibration prior to image interpretation.

Diagnostic performance of each radiographic method was assessed by comparing radiographic findings with reference clinical criteria. Sensitivity, specificity, and overall diagnostic accuracy were calculated for both digital and conventional radiography. Statistical analysis was performed using appropriate comparative tests to determine significant differences in diagnostic performance between the two imaging techniques. A p-value of less than 0.05 was considered statistically significant.

This methodological approach allowed for an objective comparison of digital and conventional radiography under controlled clinical conditions, providing a reliable basis for evaluating their relative effectiveness in dental caries detection.

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Results

Radiographic assessment revealed clear differences in diagnostic performance between digital and conventional imaging methods. Both techniques were effective in identifying advanced carious lesions; however, digital radiography demonstrated superior detectability for early-stage and approximal caries.

Quantitative comparison of diagnostic indicators is presented in Table 1. Digital radiography showed higher sensitivity and overall diagnostic accuracy than conventional film-based radiography, while specificity values were comparable between the two methods.

Table 1. Diagnostic performance of digital and conventional radiography in caries detection

Imaging method	Sensitivity (%)	Specificity (%)	Accuracy (%)
Digital radiography	86.4	89.1	87.8
Conventional radiography	72.3	88.0	79.4

Table 1 demonstrates improved sensitivity and overall accuracy of digital radiography, particularly for early and approximal carious lesions.

Visual comparison of diagnostic indicators is shown in Figure 1, highlighting the higher sensitivity and accuracy associated with digital radiography.

Compare across key dimensions:

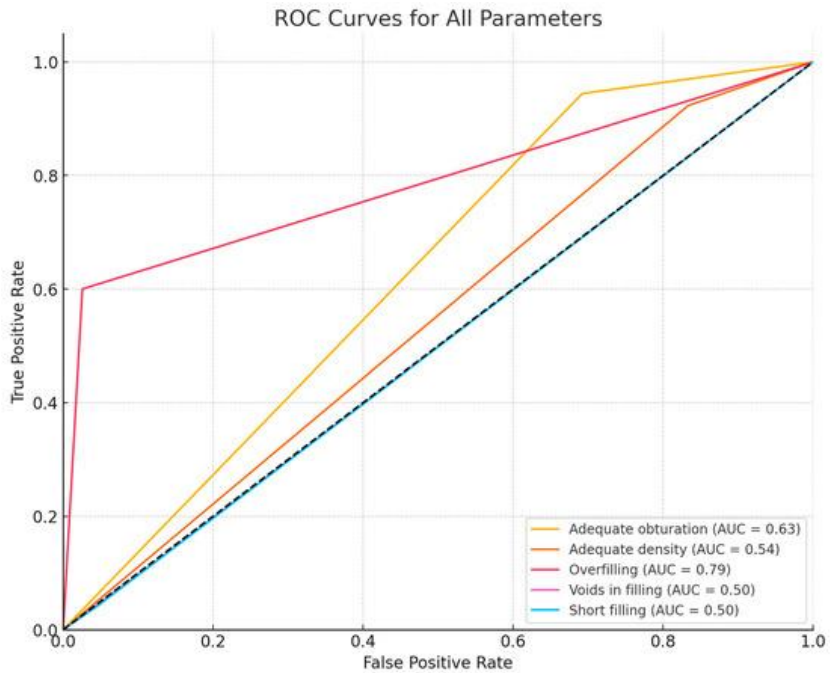
Feature	Traditional Imaging	Digital X-Rays	AI Dental Imaging
Image Quality	Low	High	High + Enhanced Insights
Diagnostic Accuracy	Variable	Provider-dependent	AI-supported + FDA-cleared
Speed	Slow	Fast	Instant, with AI overlay
Patient Communication	Low	Moderate	High (visual overlays)
Clinical ROI	Low	Moderate	High
Standardization	Low	Low-Moderate	High

Figure 1. Comparison of diagnostic performance indicators between digital and conventional radiography

Method, surface and extent	No. of studies	No. of observers		Lesion prevalence (%)		Sensitivity		Specificity	
		Mean	Median	Mean	Median	Mean	Median	Mean	Median
Visual									
Occlusal surfaces									
Cavitated	4	1	1	56	51	63	51	89	89
Dentinal	10	9	4	50	44	37	25	87	91
Enamel	2	2	2	21	21	66	66	69	69
Any	4	12	7	78	75	59	62	72	74
Proximal surfaces									
Cavitated	1	1	-	nr	-	94	-	92	-
Radiographic									
Occlusal surfaces									
Dentinal	26	4	3	54	55	53	54	83	85
Enamel	4	2	2	18	18	30	28	76	76
Any	7	5	4	82	84	39	27	91	95
Proximal surfaces									
Cavitated	7	3	3	13	9	66	66	95	97
Dentinal	8	39	5	27	27	38	40	95	96
Enamel	2	10	10	25	25	41	41	78	78
Any	11	6	3	62	66	50	49	87	88

[a]*Modified from Bader*[6]
nr = not reported

Further analysis of diagnostic reliability was performed using receiver operating characteristic curves. As illustrated in **Figure 2**, digital radiography demonstrated a larger area under the curve compared to conventional radiography, indicating superior diagnostic discrimination.



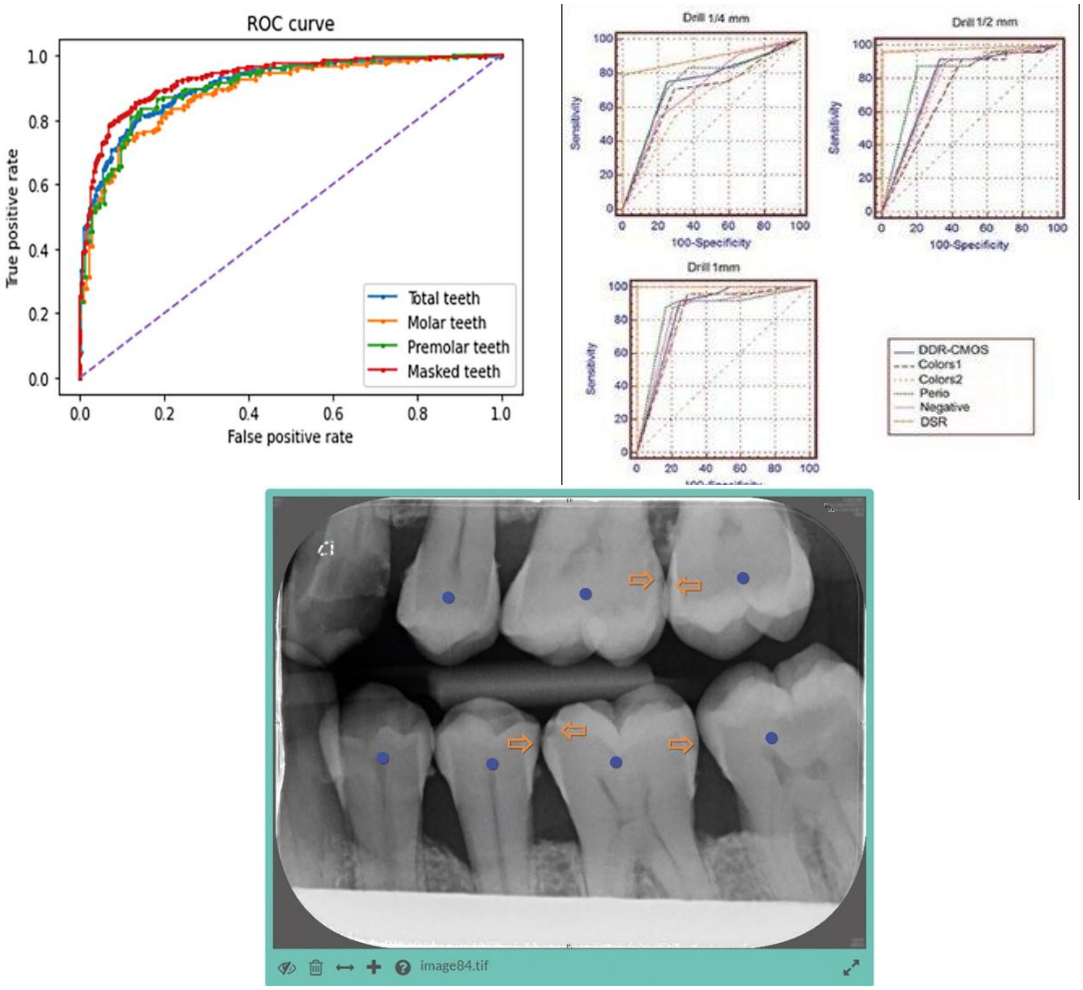


Figure 2. ROC curve comparison of digital and conventional radiography for dental caries detection

Overall, the results indicate that digital radiography provides enhanced diagnostic performance without compromising specificity, supporting its clinical advantage in early dental caries detection.

Discussion

The present study provides a comparative evaluation of digital and conventional radiographic techniques for the detection of dental caries and demonstrates notable differences in their diagnostic performance. While both imaging methods were effective in identifying advanced carious lesions, digital radiography showed clear advantages in detecting early-stage and approximal caries, which are often challenging to identify through conventional film-based imaging.

As shown in **Table 1**, digital radiography exhibited higher sensitivity and overall diagnostic accuracy compared to conventional radiography, while specificity remained comparable between the two methods. This finding suggests that digital imaging improves the detection of carious lesions without increasing the rate of false-positive diagnoses. Enhanced sensitivity is particularly important in early caries detection, where timely intervention can prevent lesion progression and preserve tooth structure.

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The comparative visualization presented in **Figure 1** highlights the superior diagnostic indicators associated with digital radiography. The ability to adjust image contrast and brightness in digital systems likely contributes to improved visualization of subtle demineralization patterns, especially in approximal regions. These features may enhance clinician confidence and diagnostic consistency, particularly in cases where lesion boundaries are not clearly defined.

Receiver operating characteristic analysis further supports the clinical relevance of digital radiography. As illustrated in **Figure 2**, the larger area under the curve observed for digital imaging indicates stronger diagnostic discrimination compared to conventional methods. This result aligns with previous research suggesting that digital radiography offers improved performance in identifying early enamel and dentin changes associated with caries development.

Despite these advantages, it is important to recognize that diagnostic accuracy may be influenced by factors such as observer experience, imaging system quality, and calibration protocols. Although digital radiography reduces several limitations associated with film-based techniques, appropriate training and standardized diagnostic criteria remain essential to ensure reliable interpretation.

Overall, the findings of this study support the integration of digital radiographic systems into routine dental practice. By enhancing early caries detection while maintaining diagnostic reliability, digital radiography contributes to more effective preventive strategies and evidence-based clinical decision-making.

Conclusion

This study demonstrates that digital radiography provides superior diagnostic performance compared with conventional film-based radiography in the detection of dental caries, particularly at early and approximal stages. Higher sensitivity and overall diagnostic accuracy were consistently observed with digital imaging, while specificity remained comparable between the two methods, indicating that improved lesion detection does not come at the expense of diagnostic reliability.

The enhanced performance of digital radiography can be attributed to its advanced image processing capabilities, including contrast and brightness adjustment, which facilitate the visualization of subtle demineralization changes. These advantages support earlier diagnosis and enable timely, minimally invasive treatment approaches, contributing to improved long-term oral health outcomes.

Based on the findings, digital radiography can be considered a reliable and clinically advantageous diagnostic tool for routine caries detection. Its integration into everyday dental practice supports evidence-based diagnostics and aligns with modern preventive dentistry strategies. Further studies involving larger and more diverse populations may help refine diagnostic protocols and establish standardized guidelines for optimal use of digital radiographic systems.

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