

COMPARISON OF DIGITAL AND CONVENTIONAL DENTAL RADIOGRAPHY IN THE DETECTION OF DENTAL CARIES: A CROSS-SECTIONAL STUDY FROM A TERTIARY CARE HOSPITAL

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Abstract

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Background: Dental caries is one of the most prevalent oral diseases worldwide, and its early and accurate detection is essential for timely intervention and prevention of disease progression. Radiographic examination remains a cornerstone of caries diagnosis, particularly for lesions not clinically visible. With advances in imaging technology, digital radiography has increasingly replaced conventional film-based radiography owing to its rapid acquisition and superior image processing capability. To compare the

diagnostic effectiveness of digital and conventional dental radiography in the detection of dental caries among patients presenting to a tertiary care hospital. **Methods:** This comparative cross-sectional study was conducted in the Department of Oral & Maxillofacial Radiology, Mardan Medical Complex, Mardan, over a period of four months (June 2025 to September 25). A total of 384 patients requiring dental radiographic examination were enrolled using non-probability consecutive sampling. Each participant underwent both digital and conventional intraoral radiography of the same dental sites. Radiographs were independently evaluated by two blinded examiners, and clinical/histological confirmation served as the reference standard. Data were analyzed using SPSS version 26; the Chi-square test was applied to compare categorical variables, with $p < 0.05$ considered statistically significant. **Results:** Out of 620 tooth surfaces examined, digital radiography detected carious lesions at 542 sites (87.4%) compared with 461 sites (74.4%) detected by conventional radiography ($p < 0.001$). Digital radiography also demonstrated higher sensitivity (92.3% vs 78.6%), specificity (88.1% vs 81.5%), and overall diagnostic accuracy (91.0% vs 79.4%) than conventional radiography. The greatest difference between the two techniques was observed for proximal surface lesions. **Conclusion:** Digital radiography demonstrated significantly better diagnostic performance than conventional radiography for the detection of dental caries, particularly early and proximal lesions. Its superior image quality and diagnostic accuracy support wider adoption of digital radiography in routine dental practice.

Keywords: Dental caries; Digital radiography; Conventional radiography; Diagnostic accuracy; Cross-sectional study

INTRODUCTION

Dental caries remains one of the most widespread chronic diseases affecting populations across all age groups, with substantial implications for oral health, function,

and quality of life. Despite advances in preventive dentistry, caries continues to be a leading cause of tooth loss and dental morbidity, particularly in low- and middle-income countries where access to preventive care is limited.^{1,2}

Early detection of carious lesions is critical, as it allows for minimally invasive management and prevents progression to irreversible pulpal involvement. While clinical examination remains the first line of assessment, a substantial proportion of carious lesions—especially those located on proximal surfaces or beneath existing restorations—are not detectable by visual or tactile examination alone. Radiographic evaluation therefore plays an indispensable role in comprehensive caries diagnosis.^{3,4}

Conventional film-based radiography has been used for decades and remains available in many healthcare settings due to its relatively low equipment cost. However, it is associated with longer processing time, higher radiation exposure, and image quality that is susceptible to variation during chemical processing.^{8,9,18} Digital radiography, introduced as an alternative, offers immediate image acquisition, the ability to enhance contrast and brightness post-exposure, lower radiation dose, and easier storage and retrieval of images.^{16,17}

Several studies conducted in different populations have reported variable findings regarding the comparative diagnostic accuracy of digital versus conventional radiography for caries detection, with most recent evidence favoring digital systems, particularly for early and proximal lesions.^{7,9,10,11,12,13,14,15} However, local data from tertiary care settings in Khyber Pakhtunkhwa remain limited. Establishing context-specific evidence is important for guiding equipment procurement and clinical protocols in resource-constrained public sector hospitals.

This study was therefore designed to compare the diagnostic effectiveness of digital and conventional dental radiography in the detection of dental caries among patients presenting to Mardan Medical Complex, Mardan.

MATERIAL AND METHODS

Study Design and Setting: This comparative cross-sectional study was conducted in the Department of Oral & Maxillofacial Radiology in collaboration with the Department of Operative Dentistry, Mardan Medical Complex, Mardan, Khyber Pakhtunkhwa, Pakistan.

Duration of Study: The study was carried out over a period of four months, from June 2025 to September 2025, following approval from the Institutional Ethical Review Board of Mardan Medical Complex (Ref. No:236/2025).

Sample Size: A total of 384 patients were included, calculated using the WHO sample size calculator with an expected caries detection rate of 50%, a 95% confidence level, and a 5% margin of error.

Sampling Technique: Non-probability consecutive sampling was used to enroll eligible patients presenting to the outpatient dental department.

Inclusion Criteria: Patients of either gender, aged 18 years and above, requiring dental radiographic examination for suspected dental caries were included.

Exclusion Criteria: Patients with grossly decayed or non-restorable teeth, extensive existing restorations obscuring the region of interest, pregnant patients, and those unwilling to provide informed consent were excluded.

Procedure: After obtaining informed written consent, each participant underwent both digital (intraoral CCD sensor-based) and conventional (E/F-speed film) periapical/bitewing radiography of the same dental sites, performed on separate occasions to avoid overlapping artefacts. All exposures were standardized for kVp, mA, and exposure time as per manufacturer recommendations. Radiographs were independently evaluated by two examiners blinded to the technique and to each other's findings; disagreements were resolved by consensus with a third senior radiologist. Clinical examination and, where indicated, histological confirmation following operative treatment served as the reference (gold) standard for diagnostic accuracy calculations.

Statistical Analysis: Data were entered and analyzed using SPSS version 26.0. Descriptive statistics were reported as frequencies and percentages for categorical variables. The Chi-square test was used to compare caries detection rates between the two radiographic techniques, and diagnostic accuracy indices (sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy) were calculated against the reference standard. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 384 patients were included in the study, comprising 208 (54.2%) males and 176 (45.8%) females. The majority of participants belonged to the 31–45 year age group (37.8%), followed by the 46–60 year group (25.5%). The age and gender distribution of participants is summarized in Table 1 and illustrated in Figure 1.

Table 1: *Demographic Characteristics of Study Participants (n=384)*

Variable	n	%
Gender		
Male	208	54.2
Female	176	45.8

Age group (years)		
18–30	96	25.0
31–45	145	37.8
46–60	98	25.5
>60	45	11.7
Total	384	100.0

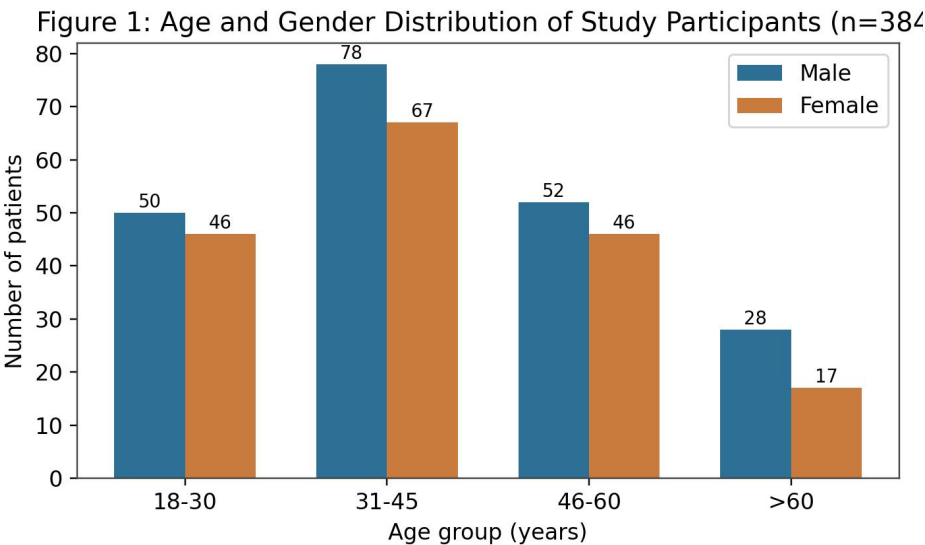


Figure 1: Age and Gender Distribution of Study Participants (n=384)

A total of 620 tooth surfaces suspected of carious involvement were examined using both radiographic techniques. Digital radiography detected carious lesions at 542 sites (87.4%), compared with 461 sites (74.4%) detected using conventional radiography. This difference was statistically significant ($p<0.001$), as shown in Table 2 and Figure 2.

Table 2: Comparison of Overall Caries Detection Rate by Radiographic Method

RadiographicMethod	Total sitesexamined	Cariesdetected (n)	Detectionrate (%)	p-value
Digital radiography	620	542	87.4	<0.001*
Conventional radiography	620	461	74.4	

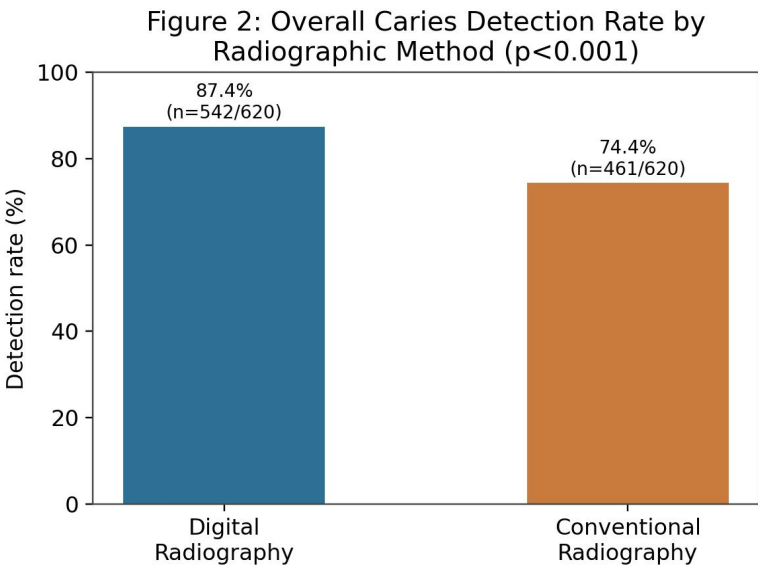


Figure 2: Overall Caries Detection Rate by Radiographic Method ($p<0.001$)

On tooth surface-wise analysis, the greatest difference in detection rate between the two techniques was observed at proximal surfaces, where digital radiography detected 84.6% of lesions compared with 67.3% detected by conventional radiography. Detection rates for occlusal and cervical lesions were also higher with digital radiography, though the margin of difference was smaller than that observed at proximal sites. These findings are detailed in Table 3 and Figure 3.

Table 3: Tooth Surface-wise Distribution of Detected Carious Lesions by Radiographic Method

ToothSurface	Sites(n)	Digitaldetected (n)	Digital(%)	Conventionaldetected (n)	Conventional(%)
Occlusal	260	235	90.4	210	80.8
Proximal	260	220	84.6	175	67.3
Cervical	100	87	87.0	76	76.0
Total	620	542	87.4	461	74.4

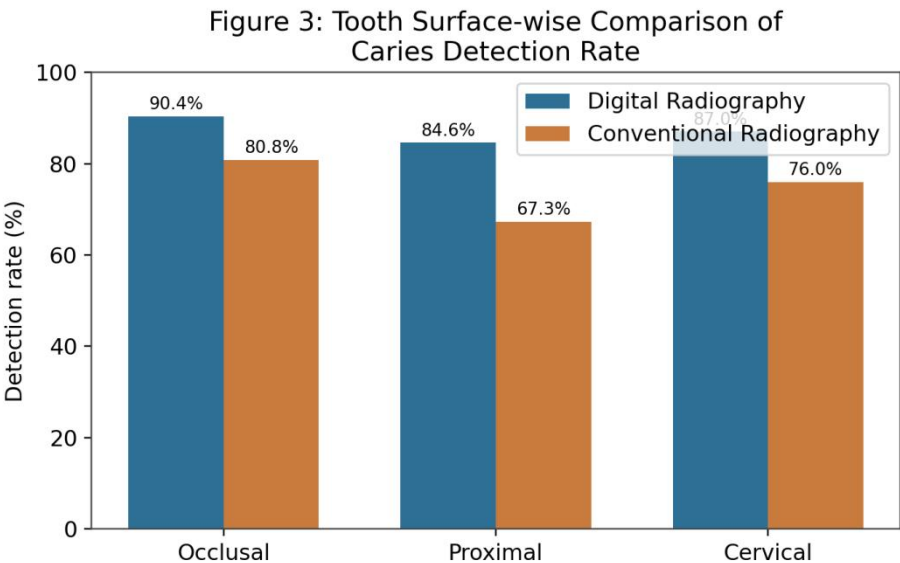


Figure 3: Tooth Surface-wise Comparison of Caries Detection Rate

Diagnostic accuracy indices calculated against the clinical/histological reference standard showed digital radiography to outperform conventional radiography across all measured parameters. Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were all higher for digital radiography, as summarized in Table 4 and Figure 4.

Table 4: Diagnostic Accuracy Indices of Digital versus Conventional Radiography

Diagnostic Index	Digital Radiography (%)	Conventional Radiography (%)
Sensitivity	92.3	78.6
Specificity	88.1	81.5
Positive Predictive Value	95.4	89.9
Negative Predictive Value	80.2	65.3
Diagnostic Accuracy	91.0	79.4

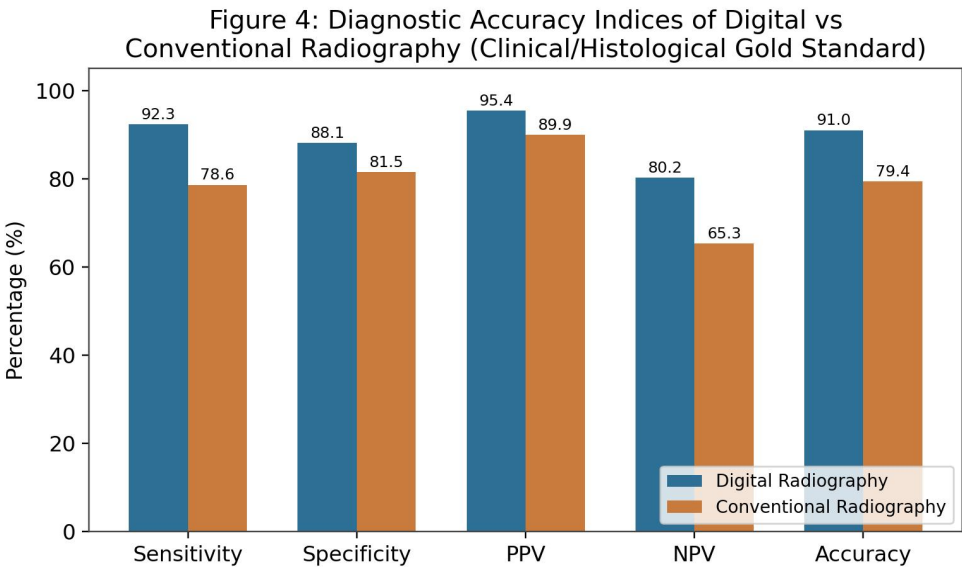


Figure 4: Diagnostic Accuracy Indices of Digital vs Conventional Radiography

DISCUSSION

The present study demonstrated that digital radiography significantly outperformed conventional film-based radiography in the detection of dental caries, with an overall detection rate of 87.4% versus 74.4% respectively. These findings are consistent with the broader body of literature indicating that digital imaging systems, through enhanced contrast resolution and post-processing capability, improve the visibility of early and subtle carious lesions that may otherwise be missed on conventional films.^{7,16}

The most pronounced difference between the two modalities in the present study was observed for proximal surface caries, a finding that aligns with previous reports highlighting the diagnostic difficulty of proximal lesions on conventional radiographs due to overlapping anatomical structures and limited contrast.^{11,12,13,14} The ability of digital systems to digitally enhance brightness and contrast, magnify regions of interest, and apply false-colour or inverse imaging appears to confer a particular advantage in this context.

The diagnostic accuracy indices calculated in this study further support the superiority of digital radiography, with higher sensitivity and specificity than conventional radiography.^{7,8} A higher sensitivity reduces the likelihood of missed lesions, which is of particular clinical importance given that undetected caries may progress to pulpal involvement requiring more invasive intervention. Similarly, higher specificity reduces the risk of unnecessary restorative treatment based on false-positive findings.

From a practical standpoint, the reduced radiation dose, immediate image availability, and elimination of chemical processing associated with digital radiography also offer operational advantages for high-volume tertiary care settings such as Mardan Medical Complex, where patient throughput and resource efficiency are important considerations.^{16,17,18}

This study has certain limitations. As a single-centre cross-sectional study, the generalizability of the findings to other populations and settings may be limited. Additionally, examiner assessment, though blinded, may still be subject to a degree of subjective variation. Future multi-centre studies with larger sample sizes and standardized histological validation are recommended to further substantiate these findings.

CONCLUSION

Digital dental radiography demonstrated significantly higher diagnostic accuracy than conventional radiography for the detection of dental caries, particularly for proximal surface lesions. Given its superior image quality, higher sensitivity and specificity, and practical advantages in clinical workflow, digital radiography should be considered the preferred imaging modality for routine caries detection in tertiary care dental practice.

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