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Comparison of artificial intelligence vs. junior dentists' diagnostic performance based on caries and periapical infection detection on panoramic images

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Abstract

Background

The advent of artificial intelligence (AI) in dentistry holds promise for enhancing diagnostic accuracy. This study aims to compare the diagnostic performance of AI and junior dentists in detecting dental caries and periapical infections using panoramic images.

Materials and Methods

A total of 200 panoramic images were selected from the dental records of a tertiary care hospital. An AI system trained on a large dataset of annotated dental images was used to analyze the selected images. Simultaneously, a group of 10 junior dentists, with 1-3 years of clinical experience, independently evaluated the same set of images. The diagnostic performance was assessed by measuring sensitivity, specificity, and accuracy for both AI and junior dentists. The gold standard for diagnosis was established by consensus from three experienced dental radiologists.

Results

The AI system demonstrated a sensitivity of 92%, specificity of 89%, and accuracy of 90% in detecting dental caries. In contrast, the junior

dentists showed an average sensitivity of 80%, specificity of 85%, and accuracy of 82%. For periapical infections, the AI system achieved a sensitivity of 95%, specificity of 90%, and accuracy of 92%, while the junior dentists had a sensitivity of 85%, specificity of 87%, and accuracy of 86%. Statistical analysis revealed that the AI system significantly outperformed the junior dentists in both diagnostic tasks ($p < 0.05$).

Conclusion

The findings suggest that AI has the potential to surpass the diagnostic capabilities of junior dentists in detecting dental caries and periapical infections on panoramic images. Integrating AI into dental practice could enhance diagnostic accuracy and support clinical decision-making.

Keywords

Artificial intelligence, dental diagnostics, panoramic images, caries detection, periapical infection, junior dentists, diagnostic accuracy.

Introduction

The application of artificial intelligence (AI) in healthcare has been rapidly expanding, offering the potential to revolutionize diagnostic processes across various medical fields. In dentistry, accurate and timely diagnosis of dental caries and periapical infections is crucial for effective patient management and treatment planning. Panoramic radiographs are commonly used diagnostic tools that provide comprehensive views of the dental arches and surrounding structures, enabling the detection of these conditions (1, 2).

Despite their widespread use, interpreting panoramic images can be challenging, particularly for less experienced practitioners such as junior dentists. Misinterpretations can lead to missed diagnoses or unnecessary treatments, impacting patient outcomes (3). AI, with its advanced image processing capabilities and machine learning algorithms, offers a promising solution to enhance diagnostic accuracy. Several studies have demonstrated the efficacy of AI in identifying various dental conditions, suggesting its potential to assist or even outperform human practitioners in specific diagnostic tasks (4, 5).

The integration of AI into dental diagnostics could significantly improve the efficiency and accuracy of detecting dental caries and periapical infections, ultimately enhancing patient care. However, comparative studies assessing the diagnostic performance of AI versus junior dentists remain limited. This study aims to fill this gap by evaluating the diagnostic capabilities of an AI system and junior dentists in detecting dental caries and periapical infections using panoramic images. By establishing a clear comparison, we aim to provide insights into the potential benefits of incorporating AI into routine dental practice.

Materials and Methods

Study Design and Image Selection

This comparative study was conducted at a tertiary care hospital, where a total of 200 de-identified panoramic radiographic images were retrospectively selected from the hospital's dental records. These images included a diverse range of cases, ensuring a comprehensive evaluation of both dental caries and periapical infections.

AI System

The AI system used in this study was a convolutional neural network (CNN) trained on a large dataset of annotated dental images. The training dataset consisted of 10,000 images, each labeled by experienced dental radiologists. The AI system was specifically programmed to identify and diagnose dental caries and periapical infections. The performance of the AI system was validated on a separate set of 1,000 images before its application in this study.

Junior Dentists

Ten junior dentists with 1-3 years of clinical experience participated in the study. Each dentist independently evaluated the 200 panoramic images for the presence of dental caries and periapical infections. Prior to the evaluation, the dentists underwent a calibration session to standardize their diagnostic criteria and reduce inter-observer variability.

Gold Standard

The gold standard for diagnosis was established by a panel of three experienced dental radiologists who reviewed the same set of 200 images. Diagnoses were made by consensus, and these served as the reference standard against which the AI system and junior dentists' performances were compared.

Diagnostic Criteria

The diagnostic criteria for dental caries and periapical infections were based on established radiographic features. Dental caries were identified by radiolucencies in the enamel, dentin, or root structure, while periapical infections were diagnosed by the presence of periapical radiolucencies indicating infection or abscess.

Data Analysis

The diagnostic performance of the AI system and the junior dentists was assessed using sensitivity, specificity, and accuracy. Sensitivity was defined as the ability to correctly identify positive cases, specificity as the ability to correctly identify negative cases, and accuracy as the proportion of correct diagnoses (both positive and negative) out of the total number of cases.

Statistical Analysis

Statistical analysis was performed using SPSS software (version 25.0). Sensitivity, specificity, and accuracy values were calculated for both the AI system and junior dentists. The performance metrics of the AI system and the junior dentists were compared using chi-square tests, with a p-value of less than 0.05 considered statistically significant.

Results

Diagnostic Performance of AI System and Junior Dentists

The diagnostic performance of the AI system and the junior dentists in detecting dental caries and periapical infections on panoramic images is summarized in Tables 1 and 2.

Dental Caries Detection

Metric	AI System	Junior Dentists (Mean)
Sensitivity	92%	80%
Specificity	89%	85%
Accuracy	90%	82%

The AI system demonstrated higher sensitivity (92%) compared to the junior dentists (80%). Similarly, the specificity and accuracy of the AI system (89% and 90%, respectively) were superior to those of the junior dentists (85% and 82%, respectively). The differences in sensitivity, specificity, and accuracy between the AI system and the junior dentists were statistically significant ($p < 0.05$).

Periapical Infection Detection

Metric	AI System	Junior Dentists (Mean)
Sensitivity	95%	85%
Specificity	90%	87%
Accuracy	92%	86%

For the detection of periapical infections, the AI system achieved a sensitivity of 95%, specificity of 90%, and accuracy of 92%. In contrast, the junior dentists had a sensitivity of 85%, specificity of 87%, and accuracy of 86%. Again, the AI system significantly outperformed the junior dentists in all three metrics ($p < 0.05$).

The results indicate that the AI system exhibits superior diagnostic performance compared to junior dentists in both dental caries and periapical infection detection. The higher sensitivity,

specificity, and accuracy of the AI system suggest its potential to enhance diagnostic accuracy and reduce diagnostic errors in clinical practice

Table 1: Diagnostic Performance in Detecting Dental Caries

Group	Sensitivity	Specificity	Accuracy
AI System	92%	89%	90%
Junior Dentists	80%	85%	82%

Table 2: Diagnostic Performance in Detecting Periapical Infections

Group	Sensitivity	Specificity	Accuracy
AI System	95%	90%	92%
Junior Dentists	85%	87%	86%

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Discussion

The findings of this study demonstrate that the artificial intelligence (AI) system significantly outperforms junior dentists in the detection of dental caries and periapical infections on panoramic images. The AI system exhibited higher sensitivity, specificity, and accuracy compared to junior dentists, underscoring its potential to enhance diagnostic accuracy in dental practice.

The superior performance of the AI system aligns with previous research indicating the efficacy of AI in dental diagnostics. For instance, Lee et al. (1) demonstrated that a convolutional neural network (CNN) algorithm achieved high accuracy in detecting dental caries on bitewing radiographs, surpassing the diagnostic performance of dental practitioners. Similarly, Tuzoff et al. (2) reported that AI could effectively identify and number teeth in panoramic radiographs, showcasing its robustness in handling complex dental images.

The integration of AI into dental diagnostics can offer several advantages. First, it can augment the diagnostic capabilities of less experienced practitioners, such as junior dentists, thereby improving patient outcomes. Misdiagnosis or delayed diagnosis can lead to adverse clinical consequences, including progression of caries and exacerbation of periapical infections (3). By providing accurate and consistent diagnoses, AI systems can help mitigate these risks.

Second, the use of AI can enhance the efficiency of dental practices. AI systems can analyze large volumes of radiographic images quickly and accurately, freeing up time for dental practitioners to focus on patient care and complex decision-making processes. This can be particularly beneficial in busy clinical settings where time constraints are prevalent.

While the results of this study are promising, several limitations must be acknowledged. The study was conducted in a single tertiary care hospital, and the findings may not be generalizable to other settings or populations. Future research should aim to validate the performance of AI systems across diverse clinical environments and patient demographics.

Additionally, the AI system used in this study was trained on a specific dataset of annotated dental images. The generalizability of AI algorithms can be influenced by the diversity and quality of the training data. Therefore, ongoing efforts to curate comprehensive and high-quality dental image datasets are essential for improving the robustness and applicability of AI systems (4-10).

Further research should also explore the integration of AI with other diagnostic modalities, such as cone-beam computed tomography (CBCT) and intraoral scanners. Combining

multiple sources of diagnostic information could potentially enhance the overall accuracy and reliability of dental diagnoses.

Conclusion

In conclusion, this study highlights the potential of AI to enhance diagnostic performance in dentistry, particularly for detecting dental caries and periapical infections on panoramic images. The superior sensitivity, specificity, and accuracy of the AI system compared to junior dentists suggest that AI can be a valuable tool in dental practice. Future research should focus on validating these findings across diverse settings and exploring the integration of AI with other diagnostic technologies.

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