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The Role and Impact of Artificial Intelligence on the Future of Dental Radiography - A Mini-Review

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Abstract

Artificial Intelligence (AI) has the potential to revolutionize dental radiography by improving diagnostic efficiency and accuracy. Dental radiography has recently benefited from the application of AI where it refers to the use of technology to enhance or speed up imaging data interpretation or to make duties easier with little to no dentist interaction. By providing a brief overview of AI's role in dental radiography, this review helps dental professionals understand how it can enhance their routine work and improve efficiency. The present paper reviews the current state of AI applications in dental radiography, identifying gaps in existing research, and exploring potential future development. AI has the potential to significantly improve dental radiography by automating and improving the interpretation process. However, there are many challenges, such as the unavailability of high-quality datasets and standardized reporting formats. Future research in AI should focus on enhancing dataset quality, creating standardized reporting formats, resolving legal and ethical issues, and offering instructions and training to dental professionals.

Keywords: Artificial intelligence, Dental radiography, Automating, Neural networks, Deep learning.

1. INTRODUCTION

Dental radiography is a crucial diagnostic tool in dentistry, providing valuable information for diagnosing, treating dental conditions and monitor oral diseases [1, 2]. However, the quality and accuracy of interpreting dental radiographs can be challenging and relies heavily on the dentist clinical experience [3, 4]. Artificial Intelligence (AI) has the potential to revolutionize dental radiography by improving diagnostic imaging efficiency and accuracy [5]. Also, the use of AI technology in dental radiography or AI-Driven Dental Imaging and Radiography can enhance or speed up imaging data interpretation or make duties easier with little to no dentist interaction [6–9]. It has proven to be advantageous in automatically identifying problems in radiographs and dental restorations, assisting in the diagnosis of complicated illnesses, and also to analyze data [10–12]. While it cannot take the role of a dentist or an oral radiologist, it can rapidly and accurately analyze radiographic images [13]. AI has proved its role in several clinical situations, like detection of anatomic landmarks, caries detection, periapical pathologies and other root pathologies within the field of endodontics, bone loss, oral cancer and forensic dentistry [14–19]. Many studies have used Convolutional Neural Networks (CNNs), a type of artificial neural network, for image interpretation, diagnosis, and treatment planning in dental radiology [20, 21]. While it has its advantages, there are several obstacles and constraints that must be addressed before its use can be generalized in clinical practice including a lack of dataset size justification and inconsistent reporting formats, which need to be standardized to further improve the AI impact in all dental disciplines [15]. By providing a brief overview of AI's role in dental radiography, this review helps dental professionals understand how it can enhance their routine work by improving the diagnostic and treatment efficiency. The present paper reviews the current state of AI applications in dental radiography, identifying gaps in existing research, and exploring potential future development.

2. LITERATURE SEARCH

A literature search for articles in English was conducted using electronic databases including PubMed, Scopus, and Web of Science, to explore 'dental radiography' and 'artificial intelligence applications' as keywords from 2000 up to June 2023. Relevant articles were reviewed to extract information on AI algorithms for image analysis, enhancement, interpretation, and automated diagnosis. In addition to conducting online searches, the reference lists of all the publications included in the study were manually scrutinized to identify additional full-text papers. This review encompassed peer-reviewed research publications sourced from academic journals, as well as conference papers sourced from proceeding books that contained full-text papers. A comprehensive evaluation was conducted on several studies that examined the use of Artificial Intelligence (AI) in the context of digital dental radiography. This encompassed the analysis of intraoral and extraoral (including the panoramic, Cone Beam Computed Tomography (CBCT), and Computed Tomography (CT) imaging techniques. This review omitted articles that solely presented an abstract or where the complete publication was not available for access. 126 articles were finalized and the findings were synthesized to provide an overview of the current state of AI in digital dental radiography. The review assessed its benefits, limitations, and potential impacts on the clinical dental practice.

3. DISCUSSION

3.1 Applications of AI in Dental Radiography

Dental imaging is one of the most interesting applications of AI in dentistry [7]. A large amount of unstructured data is commonly given to dental professionals through radiography, intraoral scanning, and face scanning. The good news is that AI-driven dental imaging software can assist in swiftly and effectively deciphering the data. Machine learning (ML) is already being utilized for diagnostic and treatment recommendations, future dental illness predictions, and automated interpretation of dental imaging (radiographs, Cone Beam Computed Tomography (CBCT), and Magnetic Resonance Imaging (MRI) scans) [22]. Additionally, it has been demonstrated that machine learning algorithms do better than dentists in diagnosing dental decay and determining whether a tooth required to be extracted, retained or restored [23, 24]. With a greater focus on diagnostic data in digital three-dimensional (3D) scans and CBCT [25, 26], it is progressively making inroads not only in general dentistry, but also in Forensic dentistry.

The regular development of the human dentition makes forensic dentistry useful for estimating age, determining sex, and identifying unknown people. Dental radiographs can provide information about the structures around the teeth, but because of the blurriness and distortion in the images, they are not ideal for clinical use. To address these issues, researchers have created automated techniques, and current research investigates the viability of AI-based techniques for forensic odontology using dental radiography [27, 28].

Key highlights from a few studies are:

Authors	Proposed/ Developed model
Nassar and Ammar [29]	Automated dental identification system using individual CNNs for postmortem identification
Zhang et al. [30]	Label tree with a cascade network for tooth recognition
Almalki et al. [31]	Dental X-rays dataset to detect and classify dental diseases
Li et al. [32]	Hybrid dental identification model
Ponprakash et al. [33]	Deep neural network with fuzzy clustering for forensic radiography-based human authentication
Wu et al. [34]	Deep learning-based approach for dental identification, utilizing panoramic radiographs
Ragda Abdalla-Aslan et al. [35]	Computer vision algorithm based on artificial intelligence, designed to automatically detect and classify various dental restorations on panoramic radiographs
Oztekin et al. [36]	Deep learning-based method for automatic detection and classification of amalgam and composite fillings on panoramic images
Uzun Saylan BC et al. [37]	Evaluated AI models in identifying alveolar bone loss in periodontitis patients

3.2 Benefits of AI in Dental Radiography

AI can substantially raise the bar for accuracy and efficiency in dental radiography. The following are some advantages of applying it to dental radiography:

a) **Enhanced diagnostic precision and accuracy:** AI algorithms can help with the analysis of data, the automatic detection and classification of dental restorations and anomalies on radiographs, as well as the diagnosis of complicated illnesses. This can increase the precision of diagnosis and assist dentists in choosing more appropriate treatments [38].

b) **Enhanced efficiency:** It can hasten the interpretation of picture data and speed up procedures that require little to no input from a dentist. This can reduce waiting times for patients and dentists alike and increase the effectiveness of dental offices as a whole [5].

c) **Enhanced treatment planning:** It can help dentists create more effective treatment plans by offering accurate and quick interpretation of radiographic images. Better patient outcomes and higher-quality care may result from this [39].

d) **Time and Cost Savings:** It can drastically save the time needed for radiographic interpretation, enabling dentists to offer quick diagnosis and treatment recommendations. Additionally, the fewer retakes required as a result of AI-enabled picture augmentation can save expenses for patients as well as dental practices [5].

3.3 Challenges in Implementing AI in Dental Radiography

Although AI has immense potential for dental radiography, there are still a number of challenges to be resolved and restrictions that need to be addressed before it can be applied in routine clinical

practice. Unstandardized reporting formats, a lack of dataset size justification, ethical issues are a few of these difficulties [5]. There is a need for larger, high-quality datasets to train AI algorithms for dental radiography. The lack of standardized reporting of dental radiography AI research makes it challenging to compare and evaluate various studies [5]. Ethical practice, informed consent, and data privacy are just a few of the moral and legal concerns that arise with using it in healthcare [40, 41]. Therefore, a number of shortcomings need to be addressed before it can be extensively used in clinical use.

3.4 Limitations Related to AI in Dental Radiography

AI has the potential to improve the accuracy and efficacy of dental radiography, but there are limitations that need to be addressed. These include bias in algorithms, transparency issues, computational capability, and the availability and quality of data, reliability etc.[39, 42]. Class imbalance is also an issue where, the difference in the number of samples representing each class within the data is deferred [43, 44]. AI systems require a large quantity of high-quality data for training, but the limited quantity and quality of data in dental radiography may reduce the efficacy of AI algorithms and lead to biased findings. To address these limitations, future AI research in dental radiography should adhere to standardized reporting formats and ensure the use of diverse and representative datasets [5]. Even though current AI techniques are yielding promising performance outcomes, it is necessary to verify the efficacy and consistency of these techniques utilizing acceptable external data received from other dental institutions or from new patients. Additionally, education and training for dental professionals on how it works, and its potential benefits can facilitate its implementation in dental radiography. Collaboration with AI experts can ensure that algorithms are developed and evaluated with dental professionals in mind. Overall, addressing these limitations and implementing these recommendations can enhance the development and application of AI in dental radiography.

4. CONCLUSION

AI has significant potential to greatly benefit dental radiography by assisting physicians in decision-making and improving patient care. However, further development and improvement are needed before it can be effectively implemented in clinical practice. While it can revolutionize the dental healthcare system by providing better treatment at lower costs, its findings are not entirely reliable due to model selection and training data, necessitating final interpretation by radiologists. Despite challenges and limitations, it offers opportunities to increase precision, efficiency, and standards in dental treatment. Further research, development, and collaboration between dentistry and AI professionals are necessary for fully utilizing AI in dental radiography. In the near future, advanced AI algorithms are expected to accurately detect and diagnose dental conditions, improving diagnosis, treatment planning, and practice efficiency using dental radiography.

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