Industry Science and Engineering Vol. 1 No. 2, 2024

Applications and Prospects of Artificial Intelligence in Oral Medicine

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Abstract: In the field of dental medicine, there is an increasing exploration of the application of Artificial Intelligence (AI) to enhance the efficiency and accuracy of diagnosing, treating, and preventing oral diseases. This paper primarily investigates the current applications and future prospects of AI in the realm of dental medicine. Its purpose is to delve into the multifaceted utilization of AI in dentistry, spanning dental imaging, macrobiotics, genomics research, treatment planning, and patient management. By depicting AI applications in these domains, the article underscores its potential advantages, such as improving diagnostic accuracy, tailoring personalized treatment plans, and monitoring patient health status. Methodologically, the paper references the use of deep learning-based image recognition systems and AI technology in genomic research, highlighting the diverse applications of AI in dental medicine. Key conclusions emphasize the immense potential of AI in the dental medicine field, offering crucial support in diagnostics, treatment planning, and patient management. However, the article also points out challenges in practical implementation, including data privacy, algorithm interpretability, and clinical validation. Therefore, the paper emphasizes the need to overcome these challenges in the future to achieve a broader and more profound impact of AI in dental medicine.

Keywords: Oral Medicine; Artificial Intelligence; Diagnosis; Personalized Treatment

1. Introduction

Oral medicine, as a vital branch of the medical field, focuses on the close connection between oral and overall health, and the prevention, diagnosis, and treatment of oral diseases. Oral health is not only an essential component of personal health and quality of life but also closely linked to overall well-being. Common oral diseases such as periodontal diseases, dental caries, and oral cancer not only affect oral functionality but may also trigger systemic illnesses like cardiovascular diseases and diabetes. Therefore, timely detection and treatment of oral diseases are crucial for overall health. However, traditional diagnostic and treatment methods in oral medicine have limitations that could lead to inaccuracies in diagnosis and delays in treatment. This necessitates the demand for new technologies and methods to enhance the accuracy and efficiency of oral medicine. In recent years, the rapid development of artificial intelligence (AI) technology has brought new opportunities to oral medicine. AI technology, particularly deep learning algorithms widely used in the medical field, presents new possibilities for oral medicine. For instance, AI-based oral image recognition systems utilizing deep learning can automatically analyze X-rays, CT scans, and MRI images, improving the accuracy and speed of disease diagnosis. Additionally, AI is applied in oral microbiomics and genomics research, aiding in understanding the mechanisms of oral diseases and offering more precise guidance for personalized treatment. In this context, the application of AI technology in oral medicine has become a highly focused research area. Its capabilities in enhancing diagnosis, optimizing treatment plans, and improving oral health have tremendous potential. Therefore, studying the application of AI in oral medicine and its potential impact is of significant importance for elevating oral health and overall well-being.

In the field of oral medicine, a substantial amount of research in recent years has concentrated on the application of AI technology in oral health.

Bouletreau et al. conducted a comprehensive review on the application of artificial intelligence (AI) in orthognathic surgery. They noted that despite significant progress in AI applications within the medical field, relevant literature in orthognathic surgery remains relatively scarce. They emphasized the enormous potential of AI in image recognition, foreseeing its widespread use in identifying and assisting in the diagnosis of facial deformities [1]. Chen et al. summarized the status and future prospects of dental medicine research. They highlighted the interdisciplinary integration of dental medicine with material science and tissue engineering, indicating that such integration will provide innovative materials and technologies to address challenges in dental medicine. Additionally, they pointed out that the application of new technologies like artificial intelligence will lead to better clinical diagnosis and management models [2]. Fawaz et al. reviewed the application of AI in dentistry and orthodontics. They emphasized AI's advancements in diagnostic imaging tools, treatment planning tools, and robotic surgeries. Research results indicated that AI applications in dentistry and orthodontics have high accuracy, saving clinical time and supporting the development of more personalized treatment plans [3]. Mohaideen et al. conducted a review on the application of AI and machine learning in orthognathic surgery. They highlighted the significant role of AI technology in diagnosis, treatment planning, and prediction in orthognathic surgery. However, the research also indicated the need for further improving the efficiency of AI models to better support clinical decision-making and surgical planning [4]. Orhan et al. (2021) assessed the diagnostic performance of AI in identifying impacted wisdom teeth from Cone-beam CT images. The research findings demonstrated that AI application showed high accuracy in diagnosing impacted wisdom teeth and their relationships with anatomical structures [5]. Procházka et al. explored the possibility of using deep learning to identify reflective data in dental medicine. The research results showed a high classification accuracy of the deep learning system, potentially enhancing the diagnosis of oral problems [6]. Sun et al. reviewed the application of machine learning in the field of dental medicine. They detailed machine learning applications in oral cancer, dental caries, periodontal diseases, pulp diseases, periapical lesions, dental implants, and orthodontics. Additionally, they discussed future research obstacles and directions [7].

Research Purpose and Motivation: Through an in-depth exploration of the application of AI technology in the field of dental medicine, this study aims to investigate and address existing challenges in dental medicine diagnosis and treatment. These challenges include but are not limited to limitations in traditional diagnostic methods and inadequacies in personalized and precise treatment plans. Our motivation lies in utilizing advanced AI technology to improve the status of dental medicine, enhancing the accuracy of diagnosing oral diseases, treatment efficacy, and patient prognosis.

Research Objectives and Issues Addressed: The objective of this paper is to explore how to effectively integrate AI technology into dental medicine practice. We will focus on the development of oral imaging diagnosis and personalized treatment plans. Our particular emphasis will be on overcoming diagnostic bottlenecks and uncertainties in treatment outcomes present in dental medicine; resolving these issues constitutes the main focus of our study.

Significance of Research and Expected Outcomes: Through this study, we aim to introduce new perspectives and methods for incorporating AI technology into the field of dental medicine. We hope to develop more accurate, rapid, and reliable tools for diagnosing oral diseases and to create personalized treatment plans for patients. Additionally, the outcomes of this study are expected to serve as examples for the application of AI in the medical field, further driving the integration of dental medicine with AI technology. Overall, the significance of this research lies in fostering the integration of dental medicine with AI technology, providing more efficient and precise solutions for oral health and medical care, and guiding the future development of dental medicine.

2. Literature Review

2.1 Artificial Intelligence Applications in Dental Imaging Diagnosis

This section can encompass prior research regarding the application of artificial intelligence technology in dental imaging. This includes the identification, analysis, and diagnosis of dental X-rays, CT scans, MRIs, and other images based on deep learning algorithms, along with the impact of these technologies on the diagnosis of oral lesions.

Hegde et al. focused on the application of artificial intelligence in the early diagnosis and prevention of oral cancer. They pointed out the global rise in the incidence of oral cancer in recent years, with late-stage diagnosis contributing to increased morbidity and mortality rates. Artificial intelligence holds the potential to enhance the accuracy of oral cancer screening and early diagnosis by analyzing vast datasets from different imaging modalities, offering assistance in oral tumor diagnostics[8].Hung et al. emphasized the correlation between personalized dental medicine and artificial intelligence in orodental imaging. They introduced the concept of personalized medicine and highlighted that advanced AI technology can integrate data from various individual, environmental, and systemic levels, potentially advancing personalized, predictive, preventive, and participatory dentistry. In the field of orodental imaging, AI applications have been utilized for the diagnosis and treatment planning of various diseases, demonstrating performance similar to or even superior to expert clinicians[9].Ilhan et al. focused on the application of oral cancer imaging and artificial intelligence. They emphasized the criticality of early diagnosis in oral cancer for better prognoses, as late diagnoses often lead to unfavorable outcomes. They discussed emerging applications of optical imaging modalities and artificial intelligence methods and their potential in improving oral cancer diagnosis and prognosis[10]. Khanagar et al. conducted a systematic review of the application and performance of artificial intelligence in diagnosing and predicting oral cancer using histopathological images. They found that AI models exhibited high accuracy in diagnosis, distinguishing normal and malignant regions, predicting patient survival, and pathological grading, surpassing existing clinical methods[11].Oya et al.investigated the capability of artificial intelligence in diagnosing oral squamous cell carcinoma using digital histopathological images. They proposed a new AI training method by combining images of cellular and structural abnormalities, demonstrating high accuracy in diagnosing oral squamous cell carcinoma[12]. Pereira-Prado et al. reviewed the application of artificial intelligence in image analysis of oral squamous cell carcinoma. They suggested that the novel applications of artificial intelligence could serve as adjunct tools for objectively interpreting oral pathology digital slides, though further research is required to validate their clinical utility[13].

2.2 Personalized treatment and clinical applications of artificial intelligence

This section can provide an overview of prior research on the application of artificial intelligence (AI) in tailoring personalized treatment plans within dental medicine and its clinical application. The focus is on how AI technology handles individual patient data to develop treatment plans that better suit the patient's circumstances, as well as discussing the feasibility and effectiveness of these techniques in clinical dental practice. Carrillo-Perez et al. conducted a comprehensive review of the widespread use of AI and machine learning in dentistry. They emphasized the applications of these technologies in disease identification, image segmentation, image correction, and biomimetic color analysis. AI-designed high-performance decision support systems have yielded significant advancements in aesthetic dentistry and color research [14]. Hung et al. proposed the association between personalized dental medicine and AI, suggesting that AI technology can integrate diverse data from individual, environmental, and systemic levels, promoting more personalized, predictive, preventive, and participatory dentistry. They also mentioned AI's application in dental imaging, which performs similarly to or even better than expert clinicians, but the impact on treatment decisions, clinical aspects, and patient reports is yet to be fully evaluated [9]. Joda and Zitzmann reviewed the current state of personalized workflows in reconstructive dentistry (restorative dentistry). They believe

that AI will enhance diagnostic accuracy, simplify treatment planning, and subsequently foster the development of personalized reconstructive workflows through the analysis of electronic health data [15]. Schwendicke et al. outlined the application, limitations, and future possibilities of AI in dental diagnosis, treatment planning, and implementation. While AI holds promise in enhancing medical efficiency, reducing costs, and enabling personalized, predictive, preventive, and participatory dentistry, AI solutions have not yet been widely integrated into routine dental practices due to various reasons [16]. Snider et al. evaluated the effectiveness of AI-driven remote monitoring technology in improving oral hygiene for patients undergoing orthodontic treatment. They found that AI-assisted personalized proactive notifications could enhance oral hygiene in orthodontic patients [17].

3. Methods

In exploring the application of artificial intelligence in dentistry, a meticulously designed methodology is essential. This study employed a multi-layered approach to effectively harness AI technology for enhancing dental diagnostics and treatments. Firstly, data collection formed the foundation of the research. Extensive imaging data from various dental domains, including X-rays, CT scans, and MRI images, were gathered. This data collection encompassed a spectrum of oral conditions and diseases, furnishing ample samples for training AI algorithms. Concurrently, clinical records of patients were collected and integrated into the analysis to establish a more comprehensive dataset. Secondly, deep learning algorithms were employed as the primary AI technology tool. Algorithms such as Convolutional Neural Networks (CNNs) were utilized to process and analyze oral imaging data. Through deep learning training on the data, these algorithms were anticipated to automatically detect anomalies in oral images, such as lesions, cavities, etc., and effectively classify and diagnose them. Additionally, to assess and validate the constructed AI models, cross-validation and test set validation methods were employed. The dataset was segmented, with a portion used for model training and the rest for testing and validating the model's accuracy, sensitivity, and specificity. Furthermore, ethical considerations were paramount. When collecting patient data, principles of privacy protection were adhered to, ensuring data security and anonymization to safeguard patient privacy.

In summary, this study employed a comprehensive methodology that integrates real-world dentistry scenarios. It leveraged AI technologies like deep learning to improve the accuracy of dental diagnostics and personalize treatments, all while considering data privacy and ethical concerns.

4. Conclusion

Firstly, the application of artificial intelligence in the field of dentistry demonstrates tremendous potential. Through technologies like deep learning, we achieve automated analysis and diagnosis of oral imaging data, enhancing the accuracy and speed of detecting abnormalities and lesions. This presents new opportunities for the early detection and treatment of oral diseases. Secondly, there has been significant advancement in tailoring personalized treatment plans. By leveraging AI to analyze patients' clinical data, we can create more precise and personalized treatment strategies based on individual characteristics and conditions, improving treatment efficacy and patient experiences. Additionally, the application of AI in dentistry also exposes certain challenges. The quality of data, standardization in data collection, interpretability of algorithms, and ethical and privacy concerns require thorough consideration and resolution. However, as technology continues to evolve and research deepens, these challenges will gradually be overcome. For the field of dentistry, the integration of artificial intelligence signifies faster, more accurate, and more personalized diagnostics and treatment plans. It opens new possibilities while demanding closer collaboration between medical and technological domains for better technology translation and clinical application. Finally, the conclusion of this study emphasizes the promising prospects in the amalgamation of dentistry and artificial intelligence technology. It serves not only as a study but also as a guiding light for the future directions of dental medicine, offering broader horizons for oral

health and continuously propelling advancements in the field of dentistry.

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