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Research Article

PERIODONTICS IN THE ERA OF ARTIFICIAL INTELLIGENCE

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A B S T R A C T

Artificial intelligence (AI) is a branch of computer science that enables the development of intelligent machines that can complete tasks without the assistance of humans. AI has undergone a significant transformation from a purely statistical tool to one of the main forces in modern medicine. AI approaches have proven to be extremely effective, accurate, and time-efficient in diagnosis and treatment planning. Recently, AI has been used extensively in the field of dentistry. Recently, several areas of periodontics have begun using AI-based models. Plaque, alveolar bone, gingiva, the relationship between systemic and periodontal health, and dental implants were all the subjects of research. AI helps periodontists provide patients with simple diagnoses and treatments. This review article focusses on the various applications of AI in the field of periodontology.

INTRODUCTION

Artificial intelligence, or AI, deals with the use of a computer to simulate intelligent behaviour with little or no human involvement.[1] When it comes to the historical part of artificial intelligence, the Logic Theorist, created by Newell and Simon in 1955, is regarded as the first AI programme and a milestone in the evolution of contemporary AI. John McCarthy first used the phrase "artificial intelligence" in 1965.[2]

Artificial intelligence has drawn plenty of attention in recent times and has developed into one of the major forces behind not only modern life—as seen in Siri, Alexa, utilizing Google, etc.—but also in medicine.[3]

In the field of medicine, AI pertains to a sub category of computer science that has the ability to assess intricate medical information. They can be employed in various clinical contexts for diagnosis, treatment, and outcome prediction due to their capacity to leverage significant relationships within data sets.[4]

The phrase artificial intelligence refers to a wide range of medical concepts, including human biology, robotics, and to diagnose medical conditions. The two primary fields of AI are the virtual and physical branches. The virtual field consists of informative techniques regarding deep learning information, electronic health records, and actively guide physician in treatment plan. Robots that help the older patients and attending surgeon are the best representation of the physical field. This branch also includes targeted nanorobots, a novel drug administration system.[1]

The key terms to comprehend the concept of artificial intelligence are:

- Artificial intelligence is defined as a machine's ability to display its own intellect. The goal was to create machines that would use data to learn how to resolve issues.
- A subcategory of AI, called machine learning utilizes algorithms to forecast results from a dataset. It enables computers to learn from data so they can solv e problems without any human involvement.
- A form of machine learning called representation learni ng involves computer algorithm
  learning the attributes needed to categorise the supplied data.[5]
- Neural networks constitute an algorithm collection that employs artificial neurons to quantify and analyze the signals. It's main aim is to create neural networks which works similar to that of humans brain.
- Subset of machine learning called deep learning makes use of a deep neural network with multiple computational units to examine incoming data. It aims to build a neural network which instantly recognizes patterns for the better recognition of the features.[6]

To be able to deliver value-based care and forecast and prevent the occurrence of dental issues, AI has been utilized in a different dental specialty as well.[3] AI is majorly applied in

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the field of dental sciences for better diagnostic accuracy and efficacy as it is crucial for attaining the greatest outcomes from treatments and providing top-notch patient care.

To assess patients and select the most appropriate course of treatment, dentists must draw on all of their expertise. Additionally, they must make accurate clinical decisions when predicting the prognosis.

Dentists might often lack the expertise needed to make the best clinical choice in a constrained timeframe. In order to help them make better decisions and perform better, AI programmes can act as their guides.[7] According to Shortliffe *et al*., Chae *et al*., Schleyer *et al*., dentists have grown reliant on computer programmes to get information for clinical decision-making.[8,9,10]

Periodontitis is a chronic inflammatory disease of the periodontium affecting the hard and soft tissues surrounding the teeth.[11] Clinicians face difficulty in correctly identifying and diagnosing periodontitis. The current standard of care emphasizes, gauging soft and hard tissues with a probe that has graduations and by radiographs. These methods have limited inter- and intra-operator precision because of variations in pressure applied while probing and radiographic orientation.

Therefore, it is difficult to accurately diagnose periodontitis given that the disease progression involves intricate connections among risk factors that are difficult for medical professionals and scientific methods to fully comprehend. It is crucial to use AI in the research of this disease with the goal to completely comprehend how these complex characteristics affect diagnosis or comprehension of the disease's aetiology.[12] This paper provides information about the utilization of machine learning in the discipline of periodontology.

Applications of AI in the field of periodontology

Diagnosis of Teeth with Jeopardized Periodontal Support and Referred for Extraction

According to Lee *et al*., a deep convolutional neural network (CNN)-based CAD system is employed in the diagnosis and also to predict the teeth whose periodontal health is destroyed. The reliability of periodontally compromised teeth (PCT) diagnosis using the CNN algorithm developed by Lee *et al*., was found to range from 76.7-81.0%, whereas the probability of detecting the teeth that should be extracted ranged from 73.4-82.8%. 82.8% of premolars were more precisely identified as PCTs versus 73.4% molars, because premolars typically have a single root, whereas molars typically have two or three roots, making the anatomy of molars more complex and difficult for a CNN to read.[13]

Correlation of systemic and periodontal health

In order to correlate systemic health issues with periodontal disease, Yauney G *et al*. developed an automated technique based on AI that integrates intraoral fluorescent porphyrin biomarker imaging, clinical tests, and machine learning. With the aid of machine learning classifier this technique can discriminate periodontal inflammation, based on the fluorescence pictures and the characteristic disease features.[14]

Diagnosis of periodontal diseases

By the utilization of artificial neural network, Papantanopoulos *et al*., distinguished patients with aggressive and chronic periodontitis by employing leukocytes, interleukins and IgG antibody titer levels, with an accuracy of 90–98%, there by aiding in the better diagnosis of periodontal diseases.[15]

Detects tooth and alveolar bone morphology

Chen CC *et al* (2023) developed a novel, deep learning (DL) ensemble model that relies on deep Convolutional Neural Network (CNN) algorithms to project tooth location in the dental arch, to recognize the shape, identify residual bone level interproximally, and to access radiographic bone loss (RBL) with the aid of periapical and bitewing radiographs. The degree of certainty for detecting tooth location was 88.8%, for detecting tooth form was 86.3%, for detecting level of the alveolar bone was 92.61%, and for estimating radiographic bone loss was 97.0%.[16]

In recent years, DL-based techniques have greatly increased in prominence. Several publications have investigated approaches for bone loss identification in intraoral radiographs. Lee *et al*. suggested a VGG-based neural network for assessing alveolar bone destruction utilizing 1740 periapical radiographs. The proposed model outperforms the work of three dentists with a preciseness of 99% and an AUC of 98%.[17]

Moran *et al*. used periapical radiographs to illustrate that the ResNet model can accurately classify locations that reflect the breakdown of the alveolar bone.[18] A disease segmentation approach employing the U-Net architecture was published by Khan *et al*. for automating the task of recognizing the defects in the bones and predicting right forms. The algorithm performed better when compared to three professionals in identifying the existence and morphology of caries.[19] Zheng *et al*. introduced an additional dense U-Net anatomically restricted technique for identifying bone lesions. CBCT images allowed the model to identify the lesion's and bone's precise shapes.[20]

Plaque detection and segmentation

You W *et al* conducted a study with an aim to develop a model based on deep learning artificial intelligence so as to identify plaque present on the deciduous teeth and to assess the model’s diagnostic efficacy. In comparison to a skilled dentist, AI model demonstrated clinically adequate results in identifying dental plaque on primary teeth.[21]

In a study conducted by Chau RC *et al*, through artificial intelligence they detected particular locations with and without gingival inflammation. This suggested that with the aid of this technique one can track the success of patients' plaque control.[22]

Imangaliyev, S *et al* conducted a study where they created an automated red fluorescent model for classifying pictures of dental plaque by employing CNN on Quantitative Light-induced Fluorescence (QLF) images.[23]

Using oral endoscopic images, Li *et al*. suggested a plaque segmentation technique determined by CNN. The outcomes demonstrated performance that was higher than dentists', with a precision of 86.42%. This method could collect and fuse information such as colour, structural arrangement in the area surrounding the plaque which aids in the better examination and detection of dental plaque.[24]

Implant dentistry

Alharbi MT and Almutiq MM conducted a study to determine if a patient requires dental implant, utilized 4 machine learning algorithms i.e., Bayesian network, random forest, AdaBoost algorithm, and improved AdaBoost algorithm. This study demonstrated how the algorithms can forecast if patient requires implants. Through these machine learning based algorithms, patients with specific diagnoses and that definitely requires implant will be focused by the decision-maker. They concluded that the precision of the enhanced AdaBoost algorithm, which they suggested, has increased prediction accuracy (91.7%). and provided noticeably better rendition when compared to the tested approaches.[25]

Revilla-León claims that the creation of osteosynthesis prediction models to forecast implant success and subsequently enhance implant designs has benefited from the application of artificial intelligence approaches.[26]

Dental implants have evolved into the go-
to procedure for restoring missing teeth. There are numerous implant companies, and each one has slightly different treatment methods. Accessories offered by the manufacturer should be used to address mechanical issues with the implant, such as screw loosening or screw fracture. However, it might be challenging for dentists at times, to recognise new implant systems by simply looking at the radiographs' pictures of the fixtures. Therefore, it is crucial to identify implants using radiography so that patients can receive the proper diagnoses and treatments.[27]

Lee *et al*. (2020), Takahashi *et al* (2020), Kim *et al* (2020), Sukegawa *et al* (2020) individually compared different implant systems. They applied artificial intelligence for the identification of various dental implant systems, and reported that AI has an accuracy of 99.5%, 51~85%, 93~98%, 86.0~93.5 respectively.[28, 29, 30,31]

CONCLUSION

AI aids by connecting systemic medicine, and dentistry thereby giving patients unprecedented levels of ease, uniformity, and clarity. Dentist will obviously not be replaced, but will instead receive more assistance to ensure that treatment programmes go well in the long run. The future of dentistry will alter as a result of the area of artificial technology and its many uses. The future of dentistry will alter as a result of artificial intelligence and machine learning.[32]

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