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Review Article

Artificial intelligence in periodontics - An overview

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ABSTRACT

Artificial Intelligence (AI) is gaining a lot of momentum in recent times in almost all walks of life. The unfolding of AI programs over the years makes analysis of complex datasets and logical interpretation of it possible article introduces the applications of AI in dentistry and further aims to emphasize the various applications specific to the field of Periodontics and Implantology. From helping the dentist interpret dental radiographs and clinically evaluate patients more efficiently to helping the dental students hone their hand skills, the possibilities are immense. Currently in clinical dentistry, AI is still a fantastic idea on paper, but with greater research and financial backing, it can most certainly be our reality in the near future.

1. Introduction

Have you ever wondered how technology can be used to make dental education more fun and more effective at the same time? How interpretation of dental x-rays can be made easier and free of inter/intra-examiner variation? How maintaining patient records can be outsourced to not another human, but a machine? Well yes, the answer to the above questions and many more is Artificial Intelligence. Artificial Intelligence (AI) simply refers to the simulation of human intelligence in machines that are programmed to think and act like humans. AI encompasses a vast spectrum of emerging technologies that influences every part of society including the field of Healthcare and Dentistry. This article aims to specifically review the various applications of AI in the field of Periodontology.

1.1. History and evolution of artificial intelligence

Alan Turing, the English mathematician laid the foundation in the 1950s, by establishing the concept of the Turing test, originally called the Imitation Game, that tested the capability of a machine to show intelligent behavior almost identical to humans. The 1956 Dartmouth Conference is regarded as the birth of AI. It was in this conference that John McCarthy coined the name Artificial Intelligence. In 1955, Allen Newell and Herbert Simon brought out the first ever AI program.[1]

In 1959, Arthur Samuel introduced the term “Machine Learning”. In the 1970s AI was subjected to critique and financial difficulties and the subsequent 10 years from 1970-1980 was called the First AI winter. The period from 1980-1987 saw a boom with the rise of “expert systems”. They are essentially AI programs that answer questions or solve problems related to a specific area of knowledge, governed by logical rules derived from expert knowledge. The late 1980’s to early 1990’s again faced many financial setbacks and came to be known as the Second AI winter. On May

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11 1997, DEEP BLUE became the first computer chess playing system to beat a living world chess champion. In the beginning of the 21^{st} century, access to huge volumes of data, cheaper and faster computers and advanced machine learning techniques were successfully applied to many problems across the globe.

2. Applications in Dentistry

AI in dentistry is a rapidly growing topic, mainly aiming to assist the dentist in providing high quality patient care and making the treatment more efficient and less time consuming. Many applications are being developed across different specializations of dentistry. A few of the recently published studies are a deep learning network to diagnose caries (Lee et al, 2018)[2], Artificial neural network for diagnosing the need of orthodontic extraction (Jung and Kim et al, 2016), Bayesian networks for developing an AI Clinical decision support system (Thanathornwong et al, 2018) and Convolutional neural network-based Treatment outcome analysis (Patcas et al, 2018) in the field of Orthodontics.[2] In the field of Oral Medicine, Speight et al in 1995 reported an Artificial neural network based system for assessing the risk of oral cancer. Nam Y, Kim HG et al in 2018, published a research with Natural language processing to convert chief complaints and history of TMJ disorders into computer language, resulting in an AI enabled system could assist the dentists in differentiating various TMJ disorders.[2,3]

3. Applications in Periodontics

3.1. Haptics-based virtual reality periodontal training simulator

This was the first haptics-based dental simulator developed by Luciano et al exclusively for Periodontics. This simulator helps students develop the necessary skillsto diagnose and treat periodontal diseases. A haptic device along with 3D images of upper and lower teeth along with gingiva can be felt by "touch". The resulting haptic feedback replicates the clinical feel of an operator's hand when using dental instruments. Steinberg et al in 2007, also incorporated recording and playback of the trainee's performance. The simulator intended to shorten the lesson time, improve the learning curve and allow unlimited practice.[4]

3.2. Ultrasonographic periodontal probe

In 1998, Companion et al, first published the results of an ultrasonographic periodontal probe at NASA Langley. This probe was intended to reduce the pain and inaccuracy that is common in manual probing. It has a hollow conical tip that is filled with water for coupling of the ultrasonic beam into the tissues. Kevin Rudd et al in 2009 used the 3D parallel acoustic finite integration technique (3DPAFIT) that simulates ultrasound propagation in the tip and the complex geometries of the periodontal tissues. A software then creates the 2D and 3D geometry of the tip and the periodontal tissue structures and performs simulations which can produce realistic data which echoes corresponding to the periodontal pocket depths.[5]

3.3. Artificially intelligent olfaction in halitosis

Many breath analyzers have been developed to replace the subjective organoleptic assessment. The major drawbacks of assessment of VSCs (Volatile Sulfuric Compounds) alone, is that 1) the absence of VSCs does not mean bad breath is gone; 2) non-sulfur volatile compounds, biomarkers of systemic diseases, found in upto 15% of halitosis cases are ignored. Artificial Olfaction, is a non-invasive technique that assesses the full spectrum of exhaled volatile compounds (Barash et al, 2009; Haick et al, 2014; Nakhleh, Broza et al, 2014). It consists of an array of sensors, mainly based on nanomaterials, that semi-selectively and/or collectively assesses the composition of exhaled breath using analysis software and a database of breath patterns and then is processed toward a pattern-recognition application. A decision tree classifier then determines whether the subject suffers from oral or extra-oral halitosis and in the second case, can also draw association to different systemic diseases. Nakhleh, Amal et al, 2017 reported 20 functionalized nanomaterials-based sensors designed to successfully distinguish among 17 different systemic diseases, by analysing exhaled breath with an overall accuracy of 86%.[6]

3.4. Differentiation between aggressive and chronic periodontitis

Feres et al in 2017, tested the hypothesis by using 40 bacterial species of the subgingival microbial complexes and a linear Support Vector Machine (SVM) - based classifier to successfully differentiate between Generalised AgP in younger adults and Generalised ChP.[7]

3.5. Automated segmentation of gingival diseases from oral images

Rana, Yauney et al in 2017 reported a machine learning classifier that could distinguish between inflamed and healthy gums. After irradiation with light of 405-450 nm wavelength, the corresponding fluorescence from biomarker porphyrin was recorded using an oral imaging device. Plaque was displayed in shades of yellow and orange whereas inflamed gums was displayed in shades of magenta and red. The classifier then churns out a pixel-by-pixel segmentation of regions speculated to have gingivitis.[8]

3.6. Automated process using machine learning segmentation and correlation between oral diseases and systemic health

Rana, Yauney et al, in 2019 reported an automated process that combines the aforementioned intra-oral fluorescent porphyrin biomarker imaging, clinical examinations and machine learning to correlate systemic and periodontal health. Here, the intra-oral images were collected, segmentation was done using the aforementioned classifier and then analysis of co-occurrence rates between subject's Modified Gingival Index (MGIs) and three other sources of screenings like a self-reported medical history questionnaire, Blood Pressure (BP) and Body Mass Index (BMI) as well as single-lead ECG, optic nerve disorders etc were performed. Results showed that higher MGIs significantly corresponded with males, old age, swollen joints and a family history of eye disease. Gingivitis significantly corresponded with abnormalities in optic nerve. With the results of their study, the authors want to stress the gravity of oral health screening at the primary care level.[9]

3.7. Diagnosis and prediction of periodontally compromised teeth

Lee et al, in 2018 started a computer-aided recognition system. A prelabeled periapical radiograph dataset was supplied, to assess the diagnosis and predictability of periodontally compromised teeth (PCT). The diagnostic accuracy for PCT was 81.0 % for premolars and 76.7 % for molars and that for predicting extraction was 82.8% for premolars and 73.4% for molars. The results of this study showed similar diagnostic and predictive accuracy to that obtained by a board certified Periodontist.[10]

3.8. Diagnosis of periodontal bone loss using deep learning

Krois et al, in 2019 used AI to discover periodontal bone loss on panoramic dental radiographs. Results showed that given the limited dataset of radiographic image segments, the trained AI software showed atleast dentist-like discriminating power to assess PBL on panoramic radiographs. The authors believe that the applicability and accuracy of CNNs can be improved by integrating more imaging data such as the use of intra-oral periapical radiographs and data sources such as clinical records into the analytics.[11]

4. Applications in Implantology

1. Although the demand for dental implants is growing at a very fast rate, many studies have shown that many implants do not lead to success. Sadat, Nazari et al in 2016 developed a hybrid method to predict dental implant success. The authors presented a combined predictive model with various classifiers like Neural networks, SVM, W-J48, K-NN. The results showed that the performance of the combined classifiers were better than a single classifier with increase in sensitivity by up to 13.3 %. The authors believe that this model can a be a reliable tool to predict the success of the implant prior to the surgery.[12]
2. Lerner, Mouhyi et al in 2020, presented a protocol for using AI for the fabrication of implant-supported monolithic zirconia crowns (MZCs) cemented to individual hybrid abutments. Here, AI along with CAD software was used to fabricate the crown. The advantages being, it was time saving as well as reduced the possibility of errors and the costs of prosthetic therapy. A retrospective study of 106 implant-supported MZCs was performed and a 3-year survival and success rates of the MZCs were 99.0% and 91.3% respectively.[13]
3. Sometimes, the dentist is unable to solve the implant related issues of the patient as the implant system is unknown to the dentist. Therefore, a need to identify the implant systems without depending on the dentist's knowledge or experience. Takahashi, Nozaki et al in 2020 successfully conducted a study using a deep learning-based object detection software to identify implant systems from panoramic radiographs. The authors believe that this system could help dentists and patients alike suffering from implant related issues.[14]

4.1. Advantages and disadvantages of artificial intelligence

As seen till now, the advantages of AI are enormous and can be revolutionary in any professional sector. The accuracy brought by AI in diagnosis, the standardization of treatment procedures, ability to save treatment time by reducing routine tasks, enablement of more systematic and structured collection of patient data, and reduction in human error are some of the many benefits of AI in the healthcare setting. It also promises to make healthcare more participatory.

Having said that, we must remember that every coin has two sides. AI also has its own set of disadvantages. The most pertinent one being, the setup costs are high. Since AI is updated daily, hardware and software updates must keep pace to meet the latest requirements. AI in healthcare also has ethical challenges in terms of all the medical data that is used for training and testing of the AI programs. AI is machine based and performed by computer scientists without medical knowledge or training. This can lead to a highly analytical approach to AI applications in healthcare. Modern healthcare relies heavily on physician-patient interaction as well as physician skill.

4.2. Future of artificial intelligence in dentistry

In the future, Yo-wei Chen et al, have predicted an AI-Comprehensive Care System which before each appointment, considers the patient's history, recognizes the patient's dental radiographs from previous appointments, and evaluates the planned treatment. The AI Patient Manager assists the dentist to understand the characteristics and preferences of each patient. During the appointment, the AI Problem Detector will assist the dentist in diagnosing the problem and also recommend various treatment modalities. It will also provide feedback to the dentist during the treatment procedure which will help in reducing human error. The outcome and prognosis are then predicted.[2]

In the future, dental colleges and clinics will be able to use AI to build patient libraries containing electronic patient files, digital x-ray images and longitudinal tracking data. In addition, 3D intra-oral scanning enables distortion-free examination. Instead of each student's patient being examined by two faculty members, the patient can be scanned and the AI can provide an unbiased assessment. This provides objective feedback on the student's learning.Another idea by Yo-wei Chen et al was that dental insurance companies can use AI to enable immediate claim approvals. This ensures transparency in the process and allows patients to get dental care faster, without worrying about missing out on insurance.[2]

5. Conclusion

Artificial Intelligence is impacting lives like never before and is here to stay. As shown in this article, the uses of AI in the field of Dentistry and Periodontics in specific are multifarious and can augment the dentist's efficacy in more ways than conventional dentistry has. Whether this becomes a common practice still lies to be seen and shall be dependent on how various stakeholders – the dentists, researchers and data scientists collaborate and the extent to which private and public organizations wish to back AI with financial support.

6. Conflict of Interest

None.

7. Source of Funding

None.

References

1. Park WJ, Park JB. History and application of artificial neural networks in dentistry. *Eur J Dent*. 2018;12(4):594–601. doi:10.4103/ejd.ejd_325_18.
2. Chen YW, Stanley K, Att W. Artificial intelligence in dentistry: current applications and future perspectives. *Quintessence Int*. 2020;51(3):248–57. doi:10.3290/j.qi.a43952.
3. Tandon D, Rajawat J. Present and future of artificial intelligence in dentistry. *J Oral Biol Craniofac Res*. 2020;10(4):391–6. doi:10.1016/j.jobcr.2020.07.015.
4. Luciano C, Banerjee P, DeFanti T. Haptics-based virtual reality periodontal training simulator. *Virtual Reality*. 2009;13:69–85. doi:10.1007/s10055-009-0112-7.
5. Rudd K, Bertoncini C, Hinders M. Simulations of Ultrasonographic Periodontal Probe Using the Finite Integration Technique. *Open Acoust J*. 2009;2:1–9. doi:10.2174/1874837600902010001.
6. Nakhleh MK, Quatredeniers M, Haick H. Detection of Halitosis in Breath: Between the Past, Present and Future. *Oral Dis*. 2017;24(5):1–11. doi:10.1111/odi.12699.
7. Feres M, Louzoun Y, Haber S, Faveri M, Figueiredo LC, Levin L, et al. Support vector machine-based differentiation between aggressive and chronic periodontitis using microbial profiles. *Int Dent J*. 2018;68(1):39–46. doi:10.1111/idj.12326.
8. Rana A, Yauney G, Wong LC, Gupta O, Muftu A, Shah P, et al. Automated segmentation of gingival diseases from oral images. In: 2017 IEEE Healthcare Innovations and Point of Care Technologies (HI-POCT). Bethesda, MD; 2018. p. 144–7. doi:10.1109/HIC.2017.8227605.
9. Yauney G, Rana A, Wong LC, Javia P, Muftu A, Shah P, et al. Automated Process Incorporating Machine Learning Segmentation and Correlation of Oral Diseases with Systemic Health. *Annu Int Conf IEEE Eng Med Biol Soc*. 2019;p. 3387–93. doi:10.1109/EMBC.2019.8857965.
10. Lee JH, Kim DH, Jeong SN, Choi SH. Diagnosis and prediction of periodontally compromised teeth using a deep learning-based convolutional neural network algorithm. *J Periodontal Implant Sci*. 2018;48(2):114–23. doi:10.5051/jpis.2018.48.2.114.
11. Krois J, Ekert T, Meinhold L, Golla T, Kharbot B, Wittemeier A, et al. Deep learning for the radiographic detection of periodontal bone loss. *Scientific Rep*. 2019;9:8495. doi:10.1038/s41598-019-44839-3.
12. Moayeri RS, Khalili M, Nazari M. A hybrid method to predict success of dental implants. *Int J Adv Computer Sci Appl*. 2016;7(5). doi:10.14569/IJACSA.2016.070501.
13. Lerner H, Mouhyi J, Admakin O, Mangano F. Artificial intelligence in fixed implant prosthodontics: a retrospective study of 106 implant-supported monolithic zirconia crowns inserted in the posterior jaws of 90 patients. *BMC Oral Health*. 2020;20(1):1–6.
14. Takahashi T, Nozaki K, Gonda T, Mameno T, Wada M, Ikebe K, et al. Identification of dental implants using deep learning-pilot study. *Int J Implant Dent*. 2020;6(1):53. doi:10.1186/s40729-020-00250-6.

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