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Artificial Intelligence (AI) In Dental Clinical Practice

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Abstract:
Artificial intelligence (AI) characterized as the ability of a machine to mimic human intelligence, has been a breakthrough in technological advancements during the last few decades and has made a huge impact on our everyday life. In current scenario, it has become necessary for the dental professionals too to get oriented with clinical as well as technological advancement to provide easy, rapid, relatively cost-effective and excellent patient care. In dentistry, artificial intelligence has been playing a significant role in improving diagnosis, treatment planning and quality of patient care. But dental practice involves more than just disease diagnosis and includes evaluating correlation between clinical and radiographic findings and administering customized definitive treatment to the patients. Hence, AI cannot replace dentists but can definitely help reducing his efforts and assisting him in decision making. This review provides information about the existence of this new technology, its current applications and its influence on dental practice.

Keyword: *artificial intelligence; deep learning; machine learning; neural network.*

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I. Introduction

"Can machines think?" — This was the question propounded by the legendary British mathematician Alan Turing in a seminal paper of 1950. Commencing with that blunt query, the field of innovation has experienced a spectacular development. One of the most fascinating parts of the human body, the brain, has piqued the interest of scientists and researchers since decades. Their several attempts to mimic the cognitive processes of humans has led to the birth of 'Artificial Intelligence (AI)'.[1] What once seemed like science fiction is now becoming a reality!

II. What Is Artificial Intelligence (AI)?

AI is defined as "the ability of a device to perform functions normally associated with human intelligence, such as reasoning, learning and self-development". It is a branch of computer science and engineering that refers to the study of intricate computational models that follow a sequence of operations known as algorithms designed to perform a specific task. Presently, the most commonly used subdomain of AI is Machine Learning (ML) and, more recently, Deep Learning (DL). [2]

Machine Learning, first referred by Arthur Samuel, is a type of AI algorithm and the model is "trained" to recognize statistical patterns in a given data set known as the training data in order to recognize similar patterns in new data known as the test data. [3]

Deep Learning is a sub-branch of ML, where the models are trained using artificial neural networks (ANN) and is precisely useful for complicated data. ANN is a structure composed of many small communicating units called neurons organized in layers. A neural network is composed of an input layer, an output layer and multiple hidden layers in between. The presence of numerous neural layers between input and output contribute to a more sophisticated performance like setting up of differential diagnosis. As a general rule, the "deeper" the network (more layers) and more the rounds of training, the better will be the performance of the network. [4]
In medicine and dentistry, one of the most commonly used subclasses of ANN is the convolutional neural network (CNN) which uses three-dimensional data for image classification and object recognition tasks. [5]

III. Birth Of The Thinking Machine

From the Turing test's introduction to ChatGPT's celebrated launch, AI's historical milestones have forever altered the lifestyles of the modern society. The beginning of AI dates back to 1936 when Alan Turing, a

British mathematician, demonstrated the feasibility of a universal calculator, also known as the "Turing machine", which was capable of solving any problem using an algorithm.[6] The first AI program, "The Logic Theorist", produced by Newell and Simon in 1955, signaled the commencement of the modern AI era. John McCarthy, regarded as 'Father of AI', in 1956 subsequently coined the term "Artificial Intelligence" but it started to gain much recognition from 1980s with the advent of neural networks.[7]

IV. Applications In Clinical Dental Practice

The field of AI has experienced incredible growth and development over the past two decades and has enormous potential to improve patient care and drive major advances in healthcare. Since, Dentistry is one of the areas where technology is most widely used, it is a very open area for developments in technology and the adaptation of AI applications. The potential applications of AI in clinical dental practice are as follows: [8-13]

Dental education

Student education: AI applications aim to change the traditional structure of dental education by improving the quality of learning, teaching, evaluation and feedback mechanisms. AI applications are often used to virtually elaborate the clinical work on patient and studies conducted in this regard has shown that students develop a competency-based clinical skill faster with these systems than with traditional simulator units.

Patient education: Application of AI improves communication between the clinician and patient. AI guided explanation of dental procedures can improve patient understanding through better visualization and ensure greater patient trust in the dental procedures.

Patient management

Virtual dental assistants powered by AI can perform several duties in the dental office with more accuracy and less manpower. It can inform about patient's medical history and treatment records, schedule visits, organize insurance and paperwork. In dental emergencies, especially if the practitioner is not available, the patient has the option of emergency tele-assistance. Tele-dentistry can also be used to monitor patient compliance and progress of treatment.

Oral Medicine and Dento-maxillofacial Radiology

Computer-based diagnosis has become much popular and reliable because of its capability to spot and diagnose lesions which the human eye may miss. AI can aid in the detection and classification of potentially malignant disorders and can identify a large population's genetic propensity for oral cancer. Researchers noted AI-aided improved prediction of cancer and cervical lymph node metastasis and better selection of treatment options, thereby reducing unnecessary treatment protocols.

Artificial intelligence applications are particularly promising in the field of dento-maxillofacial radiology. In radiology practice, findings are visually evaluated and interpreted by radiologists from diagnostic radiographs. However, this assessment can often be subjective and time-consuming. In contrast, AI-based algorithms provide quick and reliable means of image analysis, image quality improvement and aid in diagnosis. It further assists the physicians to choose the most appropriate imaging procedure based on appropriateness and level of emergency. Various applications include automated teeth identification, location of landmarks which are of low contrast or overlapping thereby making manual detection difficult, improved diagnostic accuracy of dental caries, periodontal diseases, vertical root fractures, periapical pathologies, osteosclerosis, odontogenic cysts and tumors, salivary gland disorders, maxillary sinus pathologies and intra or extra articular temporomandibular joint diseases, diagnosis of sleep disorders by automated landmark location and image identification of airway obstruction, treatment planning in implant placement, orthognathic surgery and surgical applications planned for various pathologies reducing the rate of inaccurate and incomplete diagnosis when dento-maxillofacial radiologist is unavailable and in interventional radiology, AI can predict the outcomes and/or the benefits of a treatment before actually performing a specific treatment in a specific patient thereby reducing unnecessary interventions, reducing healthcare costs and dramatically decreasing the risk for the patient.

Periodontology

Periodontitis is an extremely prevalent disease worldwide. Current best practices predominantly involve the use of a graduated instrument to measure soft tissues and radiographic imaging to evaluate hard tissues. However, inconsistent penetrating pressure and changes in radiographic projection angle make these methods less reliable. AI models have been developed for detection of plaque with intraoral photographs and fluorescent imaging, diagnosis of oral microbiota, classification of halitosis, classification of periodontal diseases, detection and calibration of periodontal bone level, assessment of requirement of extraction for periodontally compromised

teeth and classification of peri-implant diseases and conditions and have shown comparable and even better results than manual analysis.

Dento-maxillofacial Surgery

Introduction of robotic surgery in oral and maxillofacial surgery has been the greatest contribution of AI where human body motion and intelligence is imitated by robots while performing surgery under the guidance of expert. The dental implant placement, removal of tumors and foreign objects, biopsies, and temporomandibular joint surgery are examples of image-guided maxillofacial surgery procedures which ensure higher intraoperative accuracy, lesser operation time and safer manipulation around delicate structures, potentially reducing the need for revision surgeries.

Conservative Dentistry and Endodontics

Conservative dentistry treats structural deformities caused by dental hard tissue diseases, most commonly dental caries with protective, restorative, and aesthetic methods. Dental caries can be detected in periapical and bitewing radiographs. But, high enamel density due to the anatomy of the region may cause the demineralization area formed by caries to remain hidden in the radiography. High-performance results have been achieved using different DL-based CNN methods in identifying these treacherous lesions.

In endodontics, artificial intelligence is gaining more relevance as minute alterations at the level of a single pixel that the human eye could miss can be detected using AI-based networks. AI models can aid in early detection of periapical lesions, preventing it from disseminating into other tissues. It can identify not only the alveolar bone loss but can also quantify its extent to categorize the severity of periapical lesions. It can further differentiate radiographically similar lesions like periapical cyst and granuloma, thereby eliminating the need for elaborate surgical procedure. CNN may be a useful tool for identifying vertical root fractures in both intact and root-filled teeth using panoramic radiographs. It also provides a rapid, accurate and effective clinical approach to the understanding of different types of root and root canal systems, location and classification of canal orifices and determination of the working length of root canal. However, one of the system's strongest aspects is its ability to correctly forecast the requirement of retreatment in a particular case or to assess the prognosis of retreatment. In regenerative endodontics, it can predict stem cells' survival following microbial invasion.

Orthodontics

In orthodontic treatments, it is essential to plan treatments carefully to achieve predictable outcomes for patients with malocclusion. AI has the immense potential to aid in the clinical decision-making before initiating irreversible procedures like tooth extraction. AI-aided automatic cephalometric analysis and skeletal relationship classification reduce workload and save time. Moreover, studies involving AI-aided orthognathic treatment to enhance facial attraction concluded that the patients looked a year younger and their attractiveness increased by 74.7%. However, the most talked-about recent invention is personalized orthodontic care powered by AI. The AI-assisted aligners promise to eliminate multiple laboratory procedures, shorten treatment times and simplify appointment schedules in addition to providing accurate treatment execution and progress monitoring.

Prosthetic Dentistry

Prosthetic dental treatment aids in rehabilitation of lost substance in natural teeth, missing teeth and oral and maxillofacial tissue defects with artificial materials. Although the popularity of implant applications has increased in eliminating tooth deficiencies, removable prostheses are still used as the cheaper alternative. However, depending on the design, patients may complain of discomfort and aesthetic issues leading to problems such as not using the prosthesis. For this purpose, a clinical decision support model can aid to produce improved removable prostheses. On the other hand, ‘digitizing the impression procedure’ and ‘computer aided design and computer aided manufacturing (CAD/CAM) technology’ have revolutionized dental practice through creation of customized 3D models of dental crowns, laminates and veneers that meet the highest standards for fit, function and aesthetics, replacing the time-consuming and labor-intensive traditional casting process and reducing the likelihood of human error. Furthermore, virtual reality simulation (VRS) technology can be used to simulate post-treatment facial profiles, thereby serving as a motivational tool for patients.

Pediatric Dentistry

It is a branch of dentistry that deals with the examination and treatment of primary and permanent teeth in infants, children and young adults. Researchers have developed AI-based algorithms for assessing children’s oral health status and treatment needs, as a means for screening purposes in schools, for prediction of individual pain level and analgesia responses for postoperative pain management, to facilitate communication in age groups who have difficulty in describing their pain and in individuals with disabilities, for the automatic detection and classification of teeth affected by Molar-Incisor Hypo-mineralization in intraoral photographs, for improved

detection of dental plaque which predispose to various oral diseases and to facilitate the early diagnosis of missing or supernumerary teeth and help dentists to find more accurate treatment options saving time and effort.

Oral Pathology

In the field of Oral Pathology, AI has made significant advancements. A CNN model has been developed to distinguish normal from pathological tissues of dysplasia and malignancies in the oral region using auto-fluorescent and white light images obtained by intraoral scanning devices. It has been shown to be a promising aid in improving diagnostic precision, speed and efficacy of detecting intraoral squamous cell carcinoma (SCC) by looking at the shape, texture and color characteristics in histopathological images. It can further predict the survival of individuals with related pathologies. CNN algorithm can reliably distinguish intra-osseous tumors like ameloblastoma and keratocystic odontogenic tumor with an accuracy comparable with those of clinical specialists. Studies further reveal superior performance of AI models in predicting the probability of BRONJ formation in the jaws after tooth extraction in patients using bisphosphonates for the treatment of osteoporosis.

Forensic Dentistry

This specialty deals with the appropriate handling and thorough evaluation of dental and skeletal elements which can be presented as evidence in the interest of justice. Determination of gender and age from skeletal remains is an important issue in forensic studies. Neural networks showed 95% accuracy in distinguishing gender in the anthropological skull and can effectively calculate skeletal age from hand-wrist radiographs. Additionally, it is employed for analyzing bite marks and predicting mandibular morphology. However, one of the most creative uses of AI is "bioprinting," which allows regeneration of living tissue and even organs and may one day be used to reconstruct oral hard and soft tissues that have been lost due to pathological causes or trauma.

Public Health Dentistry

Artificial intelligence has the potential to significantly improve public health through health protection, health promotion, health service and public health surveillance. Health protection can be achieved by emergency tele-assistance when dental professional is unreachable and through mass screening of oral and dental diseases with accuracy and precision. Health promotion can be facilitated by individualized and targeted health advice through mobile dentistry (mDentistry) where text messages can be sent automatically or via smartphone apps to encourage people to practice better mouth hygiene. AI can increase efficacy of health services through machine learning-aided pathology detection, machine learning-facilitated automated evidence synthesis and administrative application including documentation, scientific coding, storage and maintenance of patient databases, tracking patient orders, monitoring health conditions and taking preventive actions like setting up recurring reminders for patients who intend to participate in tobacco or smoking cessation programs. Public health surveillance includes data analysis at the public level to facilitate identification of consistent change in diagnostic and treatment approaches to support public health decision-making.

V. Limitations

In the breathless response to the rise of powerful new artificial intelligence, we may be overlooking the most fundamental question of all: what does it actually mean to have a mind?

By Philip Ball

Having a mind or the art of thinking is difficult to define, it is self-initialized and self-contained. Contemporary artificial intelligence excels at using structured knowledge and gleaning understanding from vast amounts of data. But it is unable to create associations as the human brain does. In complicated situations, dentists' experience is necessary to elicit medical histories, conduct physical examinations, evaluate aesthetic results and promote conversation. It's crucial to emphasize that good patient-dentist communication requires a non-verbal assessment of the patient's hopes, anxieties and expectations.

Ambiguous accountability in the use of AI systems is another concern. Who will be held responsible for a patient who faces unintentional consequences resulting from an error in the AI technology? Is it the professional’s fault, or is it the fault of the developer who built the algorithm? Substituting humans with autonomous agents will thereby continue to present a considerable challenge to our legal system for the foreseeable future.

Furthermore, the development of AI will prompt data sharing among different institutions, posing a huge challenge to protection of patient confidentiality and privacy.

Finally, the transparency of AI algorithms and data is a substantial issue. The quality of predictions performed by AI systems relies heavily on the accuracy of annotations and labelling of the dataset used in training. Poorly labelled data can lead to poor results. [14,15]

VI. Conclusion

In a nutshell, AI systems show promise as a great aid to oral health professionals. The current scenario demands the dental professionals to get oriented with clinical as well as technological advancement and integrate them into their clinical lives to provide easy, quick, relatively cost effective and excellent patient care. Though artificial intelligence can't replace all the traits of human mind, it has made a huge contribution in reducing a dentist's efforts and assisting him in decision making. On the other hand, the support of dentists is absolutely needed in order to carry the achieved developments further.

References

[1]. Grudin J. Turing Maturation: Separation Of Artificial Intelligence And Human-Computer Interaction. Interactions 2006;13(5):54-57.
[2]. Ansdit (American National Standard Dictionary Of Information Technology. New York: Springer; 1996.
[3]. James G, Witten D, Hastie T, Tibshirani R. An Introduction To Statistical Learning With Applications In R. New York: Springer; 2013.
[4]. Goodfellow I, Bengio Y, Courville A. Deep Learning. 1st Ed. Cambridge, Ma: Mit Press; 2016
[5]. Nguyen Tt, Larrivée N, Lee A, Bilaniuk O, Durand R. Use Of Artificial Intelligence In Dentistry: Current Clinical Trends And Research Advances J Can Dent Assoc 2021;87:17.
[6]. Mijwel Mm: History Of Artificial Intelligence. Comput Sci Coll Sci 2015; 1:1-6.
[7]. Muthukrishnan N, Maleki F, Ovens K, Reinhold C, Forghani B, Forghani R: Brief History Of Artificial Intelligence. Neuroimaging Clin N Am 2020; 30:393-9.
[8]. Agrawal P, Nikhade P. Artificial Intelligence In Dentistry: Past, Present, And Future. Cureus 2022;14(7): E27405.
[9]. Alzaid N, Ghulam O, Albani M, Et Al. Revolutionizing Dental Care: A Comprehensive Review Of Artificial Intelligence Applications Among Various Dental Specialties. Cureus 2023;15(10): E47033.
[10]. Dentistry-Overview Of Artificial And Augmented Intelligence Uses In Dentistry. Ada Scdi White Paper No. 1106 – 2022.
[11]. Miloglu O, Taha Guller M, Turanli Tosun Z. The Use Of Artificial Intelligence In Dentistry Practices. Eurasian J Med 2022;54(1):34-42.
[12]. Nimbulkar G, Keshwani H, Katakwar T, Chhabra Kg, Deolia S, Reche A. Artificial Intelligence: A Dental Odyssey. Indian Journal Of Forensic Medicine & Toxicology 2020;14(4):6776-81.
[13]. Praveena N, Imran Pasha M, Shenoy Rp. Artificial Intelligence In Public Health Dentistry. International Journal Of Advanced Research 2023; 11(04):1458-61.
[14]. Char Ds, Shah Nh, Magnus D. Implementing Machine Learning In Healthcare- Addressing Ethical Challenges. N Eng J Med 2018;378(11):981-3.
[15]. Khan B, Fatima H, Qureshi A, Kumar S, Hanan A, Hussain J, Abdullah S. Drawbacks Of Artificial Intelligence And Their Potential Solutions In The Healthcare Sector. Biomed Mater Devices. 2023;8:1–8.