JIDAM
eISSN 2582 - 0559
"An Official Journal of IDA - Madras Branch"©2019.
Available online

REVIEW ARTICLE

# THE SCOPE OF ARTIFICIAL INTELLIGENCE IN DENTISTRY - A REVIEW

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**ABSTRACT**

Artificial intelligence (AI) has found a number of applications in the field of medicine and dentistry with the need for collection, documentation and computation of vast patient data, in treatment planning and diagnosis as well as in dental education. Though the technological advancements including introduction of robotic surgeries for increased precision , neural networking for diagnosis, virtual assistants to help dentists with better treatment has paved way for newer avenues , AI is still in the infancy stage and cannot replace human intelligence and skill. However , the scope of AI in various fields of dentistry is enormous and its future aspects appears extremely promising .

**KEYWORDS :** Artificial intelligence , virtual assistants , dentistry , dental education

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Received : 26.7.2019
Accepted : 12.9.2019
Published : 27.12.2019

## INTRODUCTION :

The human brain is the most complex organ of the body which controls our body's internal functions and also integrates sensory impulses and information to form perceptions, thoughts and memories . Inspite of the enormous advancements in technology over time, till date , an effective model mimicking the human brain remains an enigma to researchers all over the world. Constant search for this model has led to the development of artificial intelligence (AI) , a term coined by John McCarthy in 1956 and is defined as a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior and with creation of artifacts that exhibit such behavior[1]. The various techniques of AI which are being applied in dentistry include artificial neural networks (ANN), genetic algorithms (GA), and fuzzy logic [2]. A large amount of modern computer and technologies were inspired by Aristotle's early attempts to formulate the logical thinking through his syllogisms (a three part deductive reasoning). Aland Turing, a young British polymath explored the mathematical possibility of artificial intelligence and devised the Turing test to suggest that machines can use available information and reason to solve problems like humans[3]. Following its inception in 1959 when the first computational trainable neural networks were developed, the field of medicine and dentistry has witnessed innumerable research using AI[4]. These computer systems monitor the admission and treatment of patients supported by health care professionals, from the moment of setting the time and date of examination, via opening a digital patient record, patient history taking, support in clinical diagnosis of a disease, analysis of radiographs and laboratory procedures, assistance in determination and administration of appropriate treatment. Advancements in technology has always benefitted healthcare, improved quality of patient services and served as a great tool available to medical experts.

## THE ROLE OF ARTIFICIAL INTELLIGENCE IN VARIOUS FIELDS OF DENTISTRY :

The use of AI in clinical medical and dental practice is at an early stage of development and still in the investigation phase. Currently, artificial intelligence based virtual dental assistants are available in the market,[2] which can perform a number of simple tasks in the dental clinic with greater precision, less manpower and fewer errors than human counterparts.

## AI IN PATIENT MANAGEMENT :

### THE AI SOFTWARE PERFORMS THE FOLLOWING PATIENT MANAGEMENT TASKS :

- Fixing and coordinating appointments according to the convenience of the patient and practitioner.
- Alerting the dental healthcare provider about any relevant medical history that the patient may have before every appointment (eg: History of allergy or use of prophylactic antibiotics in those patients who have had cardiovascular surgeries)
- Notifying the patients and dentists about checkups whenever any genetic or lifestyle information indicates increased susceptibility to dental diseases. (eg: periodontal screening for patients with diabetes and oral cancer screening for those who use any form of tobacco)
- Managing documentation work and insurance
- Assisting in the clinical diagnosis and treatment planning
- Setting up regular reminders for patients who are on tobacco or smoking cessation programs. etc.
- Providing emergency tele-assistance in cases of dental emergencies when the dental health care professional cannot be contacted.
- AI software enables us to create a complete virtual database for every patient, which can be extremely detailed and accessible at the same time [5,6]. The AI software can document all necessary data and present it to the dentist much faster and more efficiently than a human counterpart. (eg: collecting all necessary dental records, extra oral photographs and radiographs necessary for diagnosing any dental condition). Adding to this, the voice recognition and interactive interphases enable the software to help the dentist perform different tasks effortlessly[2].

## AI IN DIAGNOSIS:

Correct diagnosis is the key to a successful clinical practice. Adequately trained neural networks can be a boon to diagnosticians, in conditions having

multifactorial etiology[7] such as recurrent aphthous ulceration, where clinical diagnosis is made only on the basis of recurrence and by the exclusion of other factors. In a study by Dar- Odeh et al in 2006[8], data from 86 participants were used to construct and train a neural network to predict the factors appearing to be related to the occurrence of recurrent aphthous ulcers. When this was further tested using untrained data of 10 participants the results revealed most accurate predictions such as gender, hemoglobin, serum Vitamin B12, serum ferritin, red cell folate, salivary candidal colony count, frequency of tooth brushing, and the number of fruits or vegetables consumed to be related to recurrent aphthous ulceration and appropriate for use as input data to construct ANNs. Hence, when trained ANNs were tested and compared with the diagnosis of a surgeon, the results revealed high sensitivity and specificity of ANN, thereby insisting on the importance of AI in achieving correct interpretations and reducing human errors[3].

## AI IN TREATMENT PLANNING:

The neural networks when optimally trained with respect to lower third molars are found to have high specificity and sensitivity equivalent to specialist consultation in categorizing tooth to "gold standard" based on National Institutes of Health (NIH) consensus development program which describes a well defined criteria for the removal of third molars[9]. ANN can also be employed to determine if extractions are necessary before orthodontic treatment[10]. Additionally it can be used in classifying patients into aggressive periodontitis and chronic periodontitis group based on their immune response profile[11].

## AI IN ORAL MEDICINE AND RADIOLOGY :

The neural network may help in the identification of individuals with a high risk of oral cancer or precancer for further investigation or health education[12]. This could solve the need to devise a method for early detection of oral cancer which accounts for 30% of all the cancers in India[13]. GAs and ANN are a promising tool for interpreting the sizes of unerupted canines and premolars with greater accuracy in the mixed dentition period[14] and for predicting tooth surface loss, a universal problem that involves an irreversible, multifactorial, non-carious, physiologic, pathologic, or functional loss of dental hard tissues[15].

In head-and-neck imaging modalities, AI provides additional leverage owing to its unique ability to learn. It can be integrated with imaging systems such as magnetic resonance imaging and cone-beam computed tomography to identify minute deviations from normalcy that could have gone unnoticed by the human eye. Examples include the accurate location of landmarks on radiographs, which can assist in cephalometric diagnosis[2]. ANN is found to act as a second opinion to locate the minor apical foramen, thereby enhancing the accuracy of working length determination by radiographs[16] and in diagnosing proximal dental caries[17]. Due to the sufficient sensitivity, specificity, and accuracy it possesses , it is believed to act as a model for vertical root fracture detection in digital radiography[18].

## AI IN ORAL PATHOLOGY :

Artificial intelligence can be used as a useful modality in diagnosis and treatment of lesions of oral cavity due to its ability to screen and classify suspicious altered mucosa undergoing premalignant and malignant changes as even minute changes at single pixel level are detected. In the field of pathology, AI can be used to scan large number of tissue sections following histochemical and histological processing to locate minor details which aids in diagnosis and clinical decision making. Artificial intelligence can accurately predict genetic predisposition to oral cancer in a large population[19].

The AI within the Secretary-Mimicking Artificial Intelligence (SMILE) system is designed to aid pathologists to listen to voice commands and perform numerous supplementary tasks in the analysis of pathological sections and in creating semiautomatically pathological reports[20]. In computerized drug prescription systems, AI improves system efficiency and reduces the risk of wrong drug choice by a physician[21].

## AI IN ORAL AND MAXILLOFACIAL SURGERY :

The greatest application of artificial intelligence is the advent of robotic surgery where human body motion and human intelligence is simulated[22]. Successful clinical application in image guided surgery in cranial area include oral implant surgery, removal of tumor and foreign bodies, biopsy and temperomandibular joint surgery[23]. Comparative

studies in oral implant surgery indicate significantly more accuracy compared to manual freehand procedure even if performed by experienced surgeons. In addition no significant difference between experienced surgeon and trainees were found. Also, the image guidance allows more thorough surgical resection potentially decreasing need for revision procedures[19]. Overall , the advantages reported include shorter operation time, safer manipulation around delicate structures and higher intra-operative accuracy.

Another innovative application of AI includes "bioprinting" where living tissue and organs can be constructed in consecutive thin layers of cells which in the future may be used for reconstruction of oral hard and soft tissues lost due to pathological or accidental reasons and robotic surgery, where robotic surgeons perform semi-automated surgical tasks with increasing efficiency under the guidance of an expert surgeon[2].

## AI IN PROSTHETIC DENTISTRY:

In order to provide ideal esthetic prosthesis for the patient , various factors like anthropological calculations , facial measurements, ethnicity and patient preferences have been integrated by a design assistant, RaPid for use in prosthodontics. RaPiD integrates computer aided design, knowledge based systems and databases , and employs a logic based representation as a unifying medium[19]. CAD/CAM (Computer aided design/Computer aided manufacturing) application in dentistry is the process by which finished dental restoration is attained through fine milling process of ready ceramic blocks. It is used in manufacturing of inlays, onlays, crowns as well as bridges. CAD/CAM technique essentially creates a two or three dimensional model and their materialization by numerically controlled mechanics. It has replaced the time consuming and laborious process of conventional casting and reducing the human error component in final prosthesis[24].

When we consider the possibility of implementing ANN in clinical practice, it has exhibited sufficient precision for designing and chair-side manufacturing of dental prostheses, based on digital image acquisition following tooth cusps assessment[25]. It can also have a great potential in investigating the properties of dental materials such as chemical stability, wear resistance, and flexural strength[7].

In the field of implantology and surgery, AI software has helped plan surgeries to the smallest detail prior to the actual surgery.

## AI IN ORTHODONTICS :

In Orthodontics, diagnosis forms the crux of the treatment. When a proposed model was trained to assess the craniofacial skeletal and dental abnormalities in cephalometry followed by comparison with an expert opinion, the agreement between them was found to be equivalent. Moreover, the model pointed out contradictions presented in the data that were not noticed by the Orthodontists, thereby emphasising the contribution of AI in Orthodontic decision support[26].

In the field of Orthodontics, the software can perform a number of analysis on radiographs and photographs that aid in diagnosis and treatment planning[27,28]. With the advent of intra-oral scanners and cameras, the ordeal of making a dental impression is also disappearing . These digital impressions are not only quicker and more accurate but also eliminate all the laboratory steps thus drastically reducing the number of errors. With the help of Artificial Intelligence, the computer can actually guide the dentist during the entire procedure of making a digital impression and aid in making an ideal impression[29]. It can also be used to provide orthodontic consultations to general practitioners for the alignment of crowded lower teeth[7].

The CAD/CAM technologies can be used to fabricate accurate orthodontic plates and appliances[30]. Based on the information that is fed into the system including the set algorithms and statistical analysis, the AI software helps to predict tooth movement and final outcome of treatment too.

## CONCLUSION :

Apart from its role in patient care and management in various fields of dentistry , AI can also be used in dental health education. Incorporation of AI in teaching and learning process can dramatically improvise the way students perceive knowledge. By preparing the next generation of highly skilled dental experts, it will benefit educators , students as

well as patients on the long run. AI can contribute to designing an error free evaluation pattern , free of human bias compared to the differentiated curriculum followed now[31]. AI-based dental education can significantly reduce the cost of education and burden on educators. Despite the legal and ethical issues involved , the future of AI in various fields of medicine and dentistry can be infinite and the unpredictable changes it is believed to bring about can change the dynamics of human lives forever.

## FINANCIAL SUPPORT AND SPONSORSHIP:

Nil

## CONFLICTS OF INTEREST:

There are no conflicts of interest.

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