

Artificial Intelligence in Dentistry: Boom or Doom

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I. Introduction:

Human beings are one of the most superior species that survived through ages and their brain is a complex inimitable structure that is present till today. Scientists & researchers have always remained inquisitive about it and still have not been able to simulate the exact neural network and functioning that runs this whole system. Broadly it consists of multiple interlinked neurons that transmits signals throughout the human body and controls its functioning. A primitive model of the human brain's functionality was first contemplated by Plato in 400 BC (1). Since then numerous inventions have been done with the help of continuously improving new technology to simulate the closest possible model of human brain function. Culmination of these innovations is the rise of Artificial Intelligence (AI).

AI can be defined as the computational models that can act and think in a logical manner (2). AI can also be referred to as the machine intelligence that is displayed by machines rather than the natural intelligence of living creatures. It is a highly evolved and complex system that mimics the human brain functionality. Computational understanding of science and engineering fields of normally perceived higher cognitive behaviour and creation of algorithms based on such behaviour is the basis of artificial intelligence. In computer science AI research is related to the study of any system that apprehends its surroundings, follows certain guidelines such as building a comprehensive dataset, labeling and classification of the data within the dataset & training of software to increase its chances of obtaining desired results(3). Hence the term AI can be referred to in those scenarios when a machine mimics the higher cognitive functions of the human brain such as learning, reasoning, planning, perception, creativity and problem solving. Several forms of machine learning exist including supervised, unsupervised or reinforced learning. But a common factor included in all forms is the use of a comprehensive dataset.

Officially AI came into existence in the 1950s when the concept of machine intelligence was discussed among the scientific community in a conference. AI has delivered promising results in recognising patterns in specific data points and thus its use for different phases of clinical trials is also advocated.

AI can be categorised in two forms: general AI and narrow AI. General AI system applies its own intelligence to find solutions and performs problem solving by utilizing normal human cognitive abilities. It is a strong AI system while narrow AI is designed to perform a specific task and not as strong as general AI.

AI in our daily life: AI already has a strong foothold & impacting our day-to-day life substantially. Its omnipresence can be explained by its usage in practice management softwares, in offices & voice command gadgets such as Microsoft's Cortana, Amazon's Alexa and Google's Siri. Different dialects and questions that we ask from Alexa or Siri not only improvises its functionality and performance but also provides an intelligent interface for conversation. Another example of AI integrated software is in Google pixels, Samsung phones, iphones. Google's self-driving cars, AI integrated chess playing computers & jeopardy winning Watson are science fiction youth dreams that are turning into reality. IBM's Watson platform is being used in healthcare for detecting cancer cases.

AI in medicine & dentistry: After the inception of AI in 1950, numerous researches have been done to investigate its role in healthcare. In the modern healthcare world AI based treatment modalities are gaining momentum. This is mainly due to increased sensitivity & specificity of diagnosis. It removes the chances of human error and paves the way for precision medicine in a holistic manner. For successful treatment correct diagnosis plays a vital role. Thus an adequately trained system of neural networks is very much beneficial for clinicians. It becomes more evident with certain diseases that do not have any single etiological factor. In such cases thorough analysis of multiple factors is important and hence AI comes into the picture and can make this processing faster.

AI based dentistry is not a dream in this era. AI is enriching the field of dentistry in all aspects, right from the designing of dental chairs to assessing the patients' data. Modern dental chairs have transformed from the ancient manual pump ones to the hydraulic pressure chairs and finally to the electric chairs with sensors. New AI feature that is recently integrated is the voice command in the chair. These chairs will not require any physical input from the dentist and can be operated solely based on the voice command. Researchers are going to include additional features such as sensing patient's anxiety, measuring vitals, detecting procedure time, comforting the patient, signalling to the doctor when deviations from the normalcy is detected etc. AI methodologies that are being applied in the field of dentistry are: ANN(Artificial Neural Network), Fuzzy logic and GA (Genetic Algorithms). Role of AI in different streams of dentistry can be elaborated as follows.

Radiology: In head and neck imaging AI offers additional leverage because of its capability to learn and adapt. A specific algorithm can be devised to analyze the data and propose specific treatment options. Radiological data comes from different scans such as: 3D scans, cone beam computed tomography, Intra Oral Periapical X Rays/RVGS etc. AI can be integrated with this information and can identify even slightest deviations from the normalcy that might go undetected from human clinicians. For example

- a) It can assist in accurate detection of cephalometric landmarks that are used for diagnosis(2).
- b) ANN can be used to detect the accurate working length by helping in locating minor apical foramen in radiographs(4).
- c) ANN can assist in diagnosis of proximal dental caries(5).
- d) It can act as a decision support system for lower third molars treatment when trained adequately. Based on NIH consensus criteria, precision in its treatment plan is equivalent to the expert's opinion and can be categorized as gold standard(1).
- e) ANN has also given promising results in detection of vertical root fractures(6).
- f) ANN can detect the necessity of extractions before orthodontic treatment(10).
- g) Based on the immunological response of patients ANN can differentiate between aggressive and chronic periodontitis(11).
- h) In clinical practice ANN can design and manufacture chair side prosthesis with great precision(12)
- i) ANN has the capability to assess the properties of dental materials such as: flexural strength, wear resistance, chemical stability and so on(13).
- j) GA and ANN are helpful in detecting the size of unerupted canine and premolar in the mixed dentition phase(17).
- k) GA and ANN can detect the loss in tooth surface be it pathological (caries), physiological, functional, non carious or due to any other etiology(18).

Orthodontic treatment: Latest innovation in the field of AI is its integration in orthodontics to design customized treatments. With the help of 3D scans and virtual models, aligners can be printed. After collection of all data points AI creates an algorithm to detect which tooth needs to be moved, at which point how much pressure will be required. 3D aligners can execute precise treatment with the added advantage of reduced treatment time, lesser number of appointments and progress monitorization.

AI is also beneficial in detecting craniofacial dental and skeletal abnormalities in cephalometric radiographs. Combining AI's analysis with the manual expert's opinion offers a successful treatment plan. AI can facilitate the decision making in orthodontic treatment by detecting contradictory data points that might go unnoticed by the experts(8). For general dentists it can be helpful in providing consultation for crowded lower teeth arrangement(9).

Prosthetic dentistry: In restorative and prosthetic dentistry AI integration has achieved numerous beneficial results. Such as:

- a) AI aided prosthesis design and manufacturing technology has greatly improved prosthesis fit in general.
- b) AI can generate advanced restorations with better fit, improved function and unmatched aesthetics standards. For example crown designing by using dental CAD software programs.
- c) AI can design orofacial and craniofacial prosthesis with enhanced sensitivity and precision.(7)
- d) AI can perform 3D bioprinting of the soft and hard tissues and even the organs. In this technique a thin layer of tissues is constructed that can be used in the future for reconstruction of pathologically removed or accidental lost structures(2).

- e) It forms the basis for robotic surgery. Robotic surgeons along with the specialists can perform semi automated surgical tasks with increased efficiency(2).
- f) To eliminate unwanted soft tissue accumulation while taking intra oral digital scans

Endodontics: AI is very helpful in detecting accurate location of apex in endodontics and increases the chances of restoration success.

Implantology: In implantology AI can make precise surgical guides and identify the thickness of cortical bone and bone types. This information is important in identification of suitable locations for implants placement.

Oral Pathology: In the case of multifactorial disease, AI is beneficial in providing accurate diagnosis. Adequately trained neural networks help clinicians in diagnosing diseases such as Recurrent aphthous ulcers(RAS). These ulcers do not have any specific etiology and diagnosis depends mainly upon the frequency of its recurrence along with exclusion factors. A study was conducted to investigate the effectiveness of artificial neural networks in diagnosing RAS. Data from 86 patients was used to create and train the network of artificial neurons to predict the factors that could be related to RAS' etiology. It was tested upon the new dataset of 10 new participants and AI could detect multiple parameters accurately such as gender of the patient, frequency of tooth brushing, certain foods related to RAS etiology, Vit B12, serum ferritin, Hb, red cell folate.

Another disease where AI proved to be effective is TMJ internal derangements. In TMJ problems diagnosis is based upon the clinical symptoms and imaging data. When AI is trained, tested and compared its results are comparable with those of surgeons. Thus to achieve correct interpretations and to reduce the chances of human errors AI's integration is important in healthcare(14).

For oral cancers or any other precancerous condition, AI is effective for clinical examination or health education of the patients(15). Oral cancers comprise 30% of all cancers in India. If AI's integration can make early detection and prevention of cancers successful that it would be a great support for humanity(16).

Cosmetic dentistry: In luxury dentistry personalized teeth models are being created based on the virtual and augmented reality. Lasers are used for less invasive and more precise treatment.

Advantages of AI:

1. Diagnostic accuracy and improved clinical outcomes
2. Saves time
3. Procedures standardization
4. Decreased cost of procedures due to removal of unnecessary steps and process streamlining
5. Increased patient satisfaction
6. Improved access to the data

Disadvantages of AI:

1. Mechanism complexity
2. Cost incurred (Initial set up cost)
3. Data security. AI works best when maximum output is available but simultaneously it raises the question of data security, who has access to all this information and how can we continue to gather more information?
4. Data collection. Crowdsourcing is one way to collect data from a big group of users but it has not been used to collect dental radiological data, dental and medical records, 3d modeling data. Smartphone app Waze uses crowdsourced data of traffic to provide real time navigation but in healthcare nothing has been done in a concrete manner for crowdsourcing.

Future of AI in dentistry:

Like in all other areas of our life AI is making radical changes in healthcare too. In future consumers and dentists will take a drastically different approach to dental health than today.

1. AI can be integrated in the smart toothbrushes and can provide the detailed scan with the attached smart

phone app regarding cavities, hygiene and oral health. This will be like a personalized dental health coach and can even recommend details like suitable brushing techniques depending upon your teeth or which tooth needs to be brushed at which angle. These informations can even be transferred to the dentist and stored on their cloud computer.

2. AI can be used to create virtual assistants to assist dentists during procedures. These virtual assistants are designed by Dentem (Hence called D assistants). They will hear the command and then carry out tasks such as comparing radiological data, analyze available information and then provide information based suggestions to the dentist during procedures. They will be helpful in streamlining clinical tasks of scheduling appointments, inventory management, records maintenance.

3. AI can be used to optimize the manufacturing processes where sufficient volume and manufacturing equipment are available.

4. For staining in Zirconia restorations. Robotically controlled stain applicators will be beneficial in staining of crowns based on the learned stained patterns and for case specific requirements.

5. To compare and analyze periodic xrays of the patients to identify wear patterns or progression of any pathology. This data can also be used to predict the similar patterns in other patients and to prevent its future occurrence by providing preventive remedies.

6. AI can help in evidence based decision making. It can assist dentists in deciding between providing implants or dentures to the patients. AI can evaluate underlying conditions, scans and help dentists in deciding the final treatment plan in challenging cases.

Challenges: AI will have a positive impact on healthcare but it poses few challenges in front of the FDA. Quality of the software used in the designing and functioning of medical devices is the biggest problem. Validation of the software that will have the capability to learn and adapt depending upon the user data and will change its output is going to be a herculean task for the FDA.

Will AI replace dentists: Dentistry is a multidisciplinary approach. It's not just about diagnosis. Though AI integration offers supremacy for clinical practice but it can no way substitute dentists. Final call for patient treatment will always need manual interpretation for correlating data with clinical findings and to provide personalised care to each patient.

II. Conclusion

AI application in the modern world is growing by multiple folds. For a rewarding clinical practice dentists should adapt to the new concepts and integrate AI to reap the advantages. In our daily life AI technology is growing by leaps and bounds and healthcare will not be an exception to utilize positive aspects of AI in the near future.

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