# Artificial Intelligence in Dentistry: A Ray of Hope

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## ABSTRACT

Artificial Intelligence (AI) is a technology which is rapidly growing. The Artificial Intelligence in healthcare system is developing with a very bright future. In dentistry, the key applications include diagnosis and treatment guidance, patient management as well as administrative activities. Thus, this AI system allows every dentist to get familiarize with this technology as the future of dentistry is going to be an amazing combination of this new magical innovation. The requirement for proper paperwork of the patient's information, quick and dependable treatment through robotics in the area of surgery has uplifted the utilization of these software technologies in assisting the dentist to diagnose and treat the patients practically and rewardingly. However, this technological advancement is still in the phases of early stage and this article is an attempt to spotlight the role of artificial intelligence in dentistry.

**Keywords:** Artificial intelligence, Artificial neural network, Augmented reality, COVID-19, Weak artificial intelligence.

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## INTRODUCTION

This is the world of the 21st century and we are dealing with so many ups and downs in this era. It is the generation, where people are filled with new innovative ideas. If they are suffering from something, at the same time they are also planning out new things to deal with such situations. Today, we are innovating so many new technologies to provide mental, physical as well as financial support to not only our nation but also worldwide.

With a glimmer of hope, scientists have come up with a very new technology, known as "artificial intelligence" to overcome the problems of doctors, dentists, and patients as well. Artificial intelligence is defined as "a field of science and engineering concerned with the computational comprehension which is commonly known as intelligent behavior, and with the creation of artifacts that show such behavior." In the field of dentistry, AI is slowly nudging its head in radiology, orthodontic treatments, restorative and prosthetic dentistry, endodontics, implantology, and the recent addition being voice command dental chair without any physical input from doctor in the least.[1]

The use of AI in clinical, medical, and dental practice is at an early stage of development and still in the investigation phase. Currently, AI 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.

### Brief History on Artificial Intelligence

One of the most important visionary and theoretician named Alan Turing (British mathematician), in 1936 proved that a universal calculator, known as the Turing machine is possible.[3] Turing's central insight is that such a machine is capable of solving any problem as long as it can be represented and solved by an algorithm.

### Notion of AI

There are mainly two concepts that divide the whole scope of meanings and these are strong and weak AI. Strong AI was to operate in same manner as human intelligence through non-natural, artificial hardware and software reconstruction. Weak AI attempts to implement a system that develops the problem-solving ability

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by itself through learning using some of the sense and thinking mechanisms of people.[4]

To understand the concept of AI, one must be familiar with the following terms[2]:

**Machine learning (ML):** Machine learning is a branch of computer science that builds algorithms guided by data.

**Deep learning:** Specific form of learning based on algorithms of neural networks.

**Representation learning:** Representation learning is a subtype of ML in which the computer algorithm learns the features required to classify the provided data. This does not require a hand labeled data like ML.

**Artificial neural networks (ANNs):** This involves networks of highly interconnected computer processors that has the ability to learn from past examples, analyze nonlinear data, handle imprecise information, and generalize enabling application of the model to independent data thus making it a very attractive analytical tool in the field of medicine. The greatest advantage of these systems is that they have the capability to solve the problems that are too complex to be solved by conventional methods. They are useful in various areas of medicinal science like diagnosis of diseases, biomedical identification, image analysis, and data analysis.

**Clinical decision support system (CDSS):** A CDSS is a system between a broad dynamic (medical) knowledge database and an inferencing output mechanism that are a set of algorithms derived from evidence-based medical practice executed through medical logic modules. Currently, the intuitive interphase with

voice controls are designed to assist the health care professional to work more efficiently with time saving and cost effective clinical dental practice. Clinical decision support system thus provides valuable information to dental personal, patients or individuals or populations to produce faster, more systemic and superior dental health outcomes.

**Augmented reality**: Defined as "a technology that superimposes a computer-generated image on a user's perspective of the real world, accordingly giving a composite view."

**Virtual reality:** A computer-generated reenactment of a three-dimensional (3D) image or environment that can be communicated with, in an apparently real or physical path by an individual utilizing unique electronic equipment.

## ROLE OF ARTIFICIAL INTELLIGENCE IN THE FIELD OF DENTISTRY

### Role of Artificial Intelligence 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.
- Notifying the patients and dentists about checkups whenever any genetic or lifestyle information indicates increased susceptibility to dental diseases (e.g., 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.
- Artificial intelligence software enables us to create a complete virtual database for every patient, which can be extremely detailed and accessible at the same time.[5] The AI software can document all necessary data and present it to the dentist much faster and more efficiently than a human counterpart (e.g., collecting all necessary dental records, extraoral 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]

### Artificial Intelligence in Diagnosis and Treatment of Dental Diseases

#### Artificial Intelligence in Oral Medicine and Maxillofacial Radiology

The diagnoses and treatment of lesions of oral cavity can be screened and classified into suspicious altered mucosa undergoing premalignant and malignant changes with the help of AI.[6] Artificial neural networks and genetic algorithms are a promising tool for interpreting the sizes of unerupted canines and premolars with greater accuracy in the mixed dentition period and for predicting tooth surface loss, a universal problem that involves an irreversible, multifactorial, noncarious, physiologic, pathologic, or functional loss of dental hard tissues.[7] Machine learning algorithms can detect an abnormal or normal lymph node in head and neck image provided a trained radiologist who can interpret by analyzing thousands of such images which are labeled as normal or abnormal.

#### Artificial Intelligence in Oral Pathology

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.[8]

#### Artificial Intelligence in Pediatric Dentistry

Artificial intelligence enabled pain control gadgets is the new, smarter way toward injection-free pedodontics practice. The various four-dimensional goggles, movies, animations, and virtual reality-based games can be used as a behavior modification aid for pediatric patients.[9]

#### Artificial Intelligence in Periodontics

Deep learning analysis using radiographs can help in diagnosing and treatment planning of periodontal diseases by the early detection of periodontal changes[10] bone loss, and changes in bone density and detection of peri-implantitis.[11] This helps in early intervention in implantology. Artificial neural network can also effectively be used in classifying patients into aggressive periodontitis and chronic periodontitis group based on their immune response profile.[12]

Apart from all of these AI applications, the most common and straightforward is our dental chair, which a dentist utilizes all day for his patients. The dental chair has undergone a significant transformation from a traditional hydraulic chair to an electrical and fully autonomous dental chair controlled by sensors. The most recent and extra improvement is a voice command operated dental chair that does not require the dentist to do any physical effort. When a dental chair can calculate a patient's weight, vital signs, and anxiety as the patient sits in the chair for treatment, that future is not far away.

#### Artificial Intelligence in Oral and Maxillofacial Surgery

Successful clinical application in image guided surgery in cranial area includes oral implant surgery, removal of tumor and foreign bodies, biopsy and temperomandibular joint surgery.[13] 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 differences between experienced surgeon and trainees were found. Also, the image guidance allows more thorough surgical resection potentially decreasing need for revision procedures. A study on head and neck cancer attempts to use convolutional neural networks for performing segmentation of organs at risk from head and cancer in CT images.[14] Another study was performed which demonstrated that genetic programming performed the best in oral cancer prognosis when the features selected are tobacco smoking, alcohol drinking, tobacco chewing, histological differentiation of squamous cell carcinoma, and oncogene.[15] The ANN may be of great importance for the identification and grading of patients with a high risk of oral cancer or precancer and further to plan a treatment regime.

## Artificial Intelligence 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, employing a logic-based representation as a unifying medium.[16] Computer-aided design/Computer-aided manufacturing application in dentistry is the process by which is attained finished dental restoration through fine milling process of ready ceramic blocks. It is used in manufacture of inlays, onlays, crowns as well as crowns and bridges. Computer-aided design/Computer-aided manufacturing technique essentially creates a two-dimensional and 3D 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.[17]

## Artificial Intelligence in Orthodontics

Diagnosis and treatment planning can be done by analysis of radiographs and photographs by intraoral scanners and cameras.[18] This eliminates the necessity for making patient impression as well as several laboratory steps and the results are usually much more accurate compared to human perception. The tooth movement and final treatment outcome can be predicted by using algorithms and statistical analysis.[19] The most talked about and recent revolution in orthodontic dentistry is AI driven customized orthodontic treatment. Artificial intelligence is now used in various phases of orthodontics starting from diagnosis to treatment planning and follow-up monitoring. Three-dimensional scans and virtual models are useful in assessing craniofacial and dental abnormalities.[20] With the help of these 3D scans, aligners can be printed, and treatment can be customized. After these printed aligners a data algorithm is created that intelligently decides how the teeth or tooth of the patients should be moved, how much pressure should be applied, and even also recognize the pressure points for that specific tooth/teeth. The AI conjugated aligners not only provide precise treatment but also reduces the chances of error and time for treatment.

## Shortcomings of AI Use in Dentistry[21]

- Mechanism/system complexity
  - Costly setup
  - Adequate training is required
- Data are often used for both training and testing, leading to "data snooping bias."
- The outcomes of AI in dentistry are not readily applicable.

## Conclusion

The field of dentistry is filled with lots of knowledge, technologies, and art. The combination of dentistry and AI has grown tremendously in the last decade. These AI systems play a very crucial role in dentistry as a way to obtain immediate diagnosis and treatment plan for complex problems or diseases. These AI systems have a promising and magnificent upcoming future both in general dentistry and maxillofacial radiology. However, AI will never be able to fully replace the human dentist, but it will help dental professionals to perform at a higher and comfortable level by making their profession much easier without any kind of human error. The future of dentistry along with AI is very bright. This technology should be tried to be accepted by each and every generation's dental surgeon.

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