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## Artificial intelligence in dentistry and its future

Priyankar Roy \*, Lalith Vivekanand and Gurman Preet Singh

*Department of Periodontology, Mathrusri Ramabai Ambedkar Dental College and Hospital, Bangalore, Karnataka, India.*

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### Abstract

Technology is evolving every day and the latest trends in Artificial Intelligence have made dental procedures less time consuming and minimally invasive. With their application the decision making processes have become easier and faster. Patients are more comfortable and dentists are more confident about their work. This advent of technology into medical science has made both practitioners and their patients comfortable and confident about the treatment rendered and received. The use of machine learning has made the decision making process easier by stimulating human intelligence into the machines that are programmed to think like humans and mimic their actions. Artificial Intelligence has proved itself to be a boon in the field of dentistry. In future AI based comprehensive care systems are expected to have high quality patient care and help researchers know and treat more about diseases. Even though misconceptions and certain limitations about Artificial Intelligence prevails, it still continues to flourish due to its advantages in providing precision.

**Keywords:** Artificial Intelligence; Digital dentistry; Telemedicine; Robotic surgery; Nanodentistry

### 1. Introduction

Technology has undergone a great change in the last decade. Existing in an era of COVID-19 pandemic has forced the mankind to develop a lifestyle which is faster, non-exposive, and controlled at the fingertips. In medical practice precautionary measures and risk of infection has demanded the introduction of a non-invasive and minimally exposive procedures for patients. In such scenarios AI has emerged as a life saving wizardly tool. The concept of AI was introduced by John McCarthy, a mathematician from Dartmouth University in 1956 at a workshop, which credited him as the father of Artificial Intelligence [1].

Richard Bellman in 1978 defined Artificial Intelligence as “The automation of activities associated with human thinking abilities, which includes learning, decision making and problem solving” [2]. This tool has made tremendous inroads in dentistry in the past few decades and is in more demand during COVID-19 phase which shall increase with time. This has brought a change in the way of practicing dentistry in the 21<sup>st</sup> century by reducing the inaccuracy and increasing the precision. AI has been beneficial in generating rapid clinical solutions, maintaining the patient records digitally and processing them with the help of data-driven analysis, algorithms and machine learning [3]. The fundamental aspects of AI commonly incorporated in dentistry are artificial neural networks (ANN), Machine Learning (ML), fuzzy logic, telemedicine, CAD/CAM, CARS, Nanodentistry, Digital Smile Designing & Dynamic navigational implant placement.

### 2. Artificial neural network

Artificial neural networks (ANN) are highly interconnected networks inspired by biological nervous systems [4]. It has an ability to think like human the brain and interpret diseases based on the newer information [2, 5] . Recently, a developmental proposal was put forward and Google brain was introduced. This concept spoke about how an online

\*Corresponding author: Priyankar Roy; E-mail id: [roypriyankar09@gmail.com](mailto:roypriyankar09@gmail.com)

Department of Periodontology, Mathrusri Ramabai Ambedkar Dental College and Hospital, Bangalore, Karnataka, India

search engine could be made capable enough to mimic a normal human brain. The concepts of ANN in dentistry would help in rapid decision making and extraordinary memory useful in any time correlation.

### 3. Machine learning

It has been introduced as a sub branch of Artificial Intelligence [4]. It corresponds with the ability to process data obtained through a specific recognition sensor or input tool according to a predetermined learning algorithm. This aids in preparation for an artificial neural network [6].

### 4. Fuzzy logic

Introduced by Lothfi A. Zadeh in 1962, it is the science of principles of human reasoning, thinking and inference that recognizes and uses real world phenomenon to interpret outcome and diagnosis [7,8]. The concept behind this is to overcome human reasoning ability that is not accurate and precise all the time. This is an effective tool for the practitioner facing the dilemma of choosing an appropriate and an accurate treatment plan for a particular patient. It generally consists of permutation and combination of data which would help the practitioner to generate faster results and design a human makeover.

### 5. Application of artificial intelligence in different fields of dentistry

AI has played a major role in every field and every aspect of dentistry, it has helped the practitioners from maintaining the records to providing a successful treatment. The values of AI in dentistry are as follows:

- **In patient management:** It can assist in managing and maintaining patient records through a virtual database which also includes regularity of appointments. It can alert the patient and the dentist of any genetic or lifestyle mutative disease indicating increased susceptibility to dental diseases. It also helps in online emergency health consultancies [7,9]. In this time of pandemic online consultations have gained increased importance owing to which a virtual database gives easy access to the medical and dental history of the patient making it easier for dentist/ doctor to treat the patient.
- **In oral and maxillofacial radiology:** AI has great competence in the field of radiology. It helps in diagnosis and provides treatment options. Integrated with imaging systems like MRI (Magnetic Resonance Imaging) and CBCT (Cone Beam Computed Tomography) it can identify even the minute deviations from normal which can go unnoticed by the human eye<sup>7</sup>. Dental practice which was antecedently restricted to two-dimensional (2D) images can be visualized three-dimensionally (3D) as well. With the use of machine learning algorithms, abnormalities in lymph nodes can be detected in the head and neck region. Diagnocat, software made adequately with trained neural networks in Moscow, helps in analyzing and providing the diagnosis for any disease with multifactorial etiology [10].
- **In Prosthetic and restorative dentistry:** One of the essential parts of dentistry is esthetics and cosmetics. It is important to provide perfect prosthesis to the patient and in order to do that many factors have to be considered by the dentist like anthropological calculation, facial measurements, esthetics and patient preference [11]. Thus computer aided technology for precise fit of prosthesis was developed which is known as CAD/CAM. It is an acronym for computer assisted designing and computer assisted manufacturing. It was introduced into dentistry in the year 1989 by Mormann and Brandestinni in Germany [12]. This concept helps achieve the finishing of dental restorations with exactness. It helps to design inlays, onlays, crowns and bridges in less time and reduces the chances of error making [9]. An innovative tool in aesthetic dentistry is Digital smile Designing (DSD). This helps in pre visualization of new smile designing prior to the treatment and also helps the dentist to prepare a better treatment plan for the patient. It makes the use of intraoral 3D scanners instead for taking impressions which makes prosthetic dentistry less tiring.
- **In orthodontics:** Orthodontics has come miles ahead with the use of Artificial Intelligence. From unaesthetic, irritating wired braces to invisible aligners it has taken a long leap. Automated cephalometric X-ray analysis using a specialized AI algorithm has increased the efficiency of treating patients [13]. AI assisted orthodontics has also made its way into telemedicine where patients are guided over a video call about taking impressions and is sent to the concerned physicians, following which these custom aligners are sent to them.
- **In Oral and Maxillofacial surgery:** Robotics is the next generation technology which has become a part of many other specialties for quite a while now. It has been in practice as robotic assisted dentistry in treating complex cases in surgery. In the field of oral and maxillofacial surgery the facial implants are of huge importance as well. In cases of trauma and reconstruction post resection due to cancer, 3D printing has made it possible to

fabricate customized implants like zygomatic, mandibular, etc. for these patients maintaining a harmony between structure, function and aesthetics.

- **In periodontics:** Clinical attachment loss is the most common sign of periodontal diseases which determines the severity, prognosis and treatment planning. With advancements in periodontal probes like pressure sensitive probes, computer linked probes and ultrasonography it has been made possible to reproduce the measurements accurately making the procedure less cumbersome [14]. Introduction of Computer Assisted Densitometric Image Analysis System (CADIAS) has made the analysis of alveolar bone density more refined. The current breakthrough in 2019, Catalytic Antimicrobial Robots (CARS) has been successful in removal of biofilms. These are magnetically driven robots which can accurately, efficiently and controllably kill, degrade and remove generated bacterial free radical, biofilm exopolysaccharide(EPS) matrix, segregated biofilm debris [15,16].

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## 6. Dental implant

Navigational implant placements have shown great success by decreasing the incidence of maxillary sinus perforations and other chronic complications of sinus cavity and prevalence of infections. Dynamic navigation device was used with planning data and Cone Beam Computed Tomographic (CBCT) image for surgical implant insertions [16, 17].

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## 7. Nanodentistry

Nanodentistry comprises of nanomaterials, biotechnology and dental nanorobotics for maintaining comprehensive oral health [16]. This allows treatment possibilities in the fields of restorative dentistry, orthodontics, periodontics and oral medicine. The introduction of nanorobotics or nanobots in this field has made managing complicated cases at the microscopic level more precise and easier [15]. Due to their size nanobots work at atomic, cellular and molecular level. In endodontic and conservative dentistry this can be used for cavity preparation, restoration etc. In the field of orthodontics it can help in single sitting alignments and in periodontics it can offer alternative techniques to induce controlled oral analgesia and manipulate tissues to aid in managing restorative and periodontal treatment [18]. Oral hygiene can be maintained by destruction of pathogenic bacteria and plaque removal using dentifrobots. This can also change the way of drug delivery systems by nanoencapsulation and also provide new ways of bone grafting. Furthermore in the near future it can ensure us improved dental material with the help of nanosolutions. This involves the recent invention in dentistry like lab on a chip which might be in demand in future. Lab on a chip uses saliva to detect morphological, biophysical and biochemical nanoscale properties of tooth surface or oral fluid such as saliva to diagnose susceptibility of diseases such as dental caries, oral cancer etc [19].

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## 8. Future of artificial intelligence in dentistry

Artificial Intelligence is the new renaissance of dentistry. It involves itself in every aspect evolving the manual dental chairs to an electrical one with voice recognition centers to facilitate command operations by the dentist [20]. In future AI will be adorned by all dental practitioners. With the wise use of machine learning the patient records and diagnostic data can be saved virtually. This will not only help patients in maintaining health track records but also help practitioners share the data with their colleagues for consultation and case discussion in a hassle-free way.

In future, the cutting edge technologies will serve as a great assistant to the dentist by preserving their valuable time, giving them streamlined workflow and increasing their precision. AI has less bias and better judging probability, making it a great assistant to the dentist in analysis of the diseases, diagnosing them and providing an optimal treatment plan based on collected evidence. However a clinician still retains the responsibility of making the final decision.

The use of dental insurance for AI could be beneficial in future. Uploading radiographs and CT scans will give insurance companies more transparency and faster claim of insurance by the patient thus increasing patient benefits and reducing practitioner's loss [21].

Newer innovations would help clinicians master treatment plans. Nanotechnologies are expected to bring more wonders in the field of dentistry using robots and nanobots to provide an extra hand to dentists instead of replacing them. The catalytic antimicrobial robots (CARS) will enhance the oral hygiene maintenance. The trend of 3D printers are revolutionaries in the field of prosthetics and surgery by providing desired biocompatible parts in a very less period of time and making the procedure cost effective as well.

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## 9. Conclusion

The fidelity of the AI is unquestionable. With CAD/CAM giving perfect fit prosthesis with high esthetic value to the implant navigational surgeries in which, based on the 3D scans, implants are placed without any complications, AI has set its trend in the current market and will keep growing in future as well. Even though AI acts as beneficiaries a common question always hunts in the mind of practitioners; “Will the AI replace the practitioners in future?”. The answer today would be “No”. Rather it will surely make a practitioner more potent to do complicated cases. As per researchers AI is the future of helping clinicians to integrate different fields of knowledge for better patient care.

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## Compliance with ethical standards

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We hereby declare there are no conflicts of interest in connection with this paper.

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