

# ARTIFICIAL INTELLIGENCE IN DENTISTRY: A BOON FOR DENTISTS AND PATIENTS ALIKE

## Abstract

Artificial Intelligence, a flourishing branch of computer science, has helped in the creation of intelligent machines that have the power to think like humans. These machines can understand complex topics encompassing different fields. They can even solve problems by proper reasoning and logic. AI has entered all walks of life and health care and dentistry are no exception. Dental AI helps dentists treat patients with utmost precision. It can detect tooth erosion and create customized treatment strategies for different patients, thereby saving time. Unlike manual examinations, AI tools take just a split-second to identify an abnormality. Before discussing how AI is used in different fields of dentistry, let's get an idea about how it all started.

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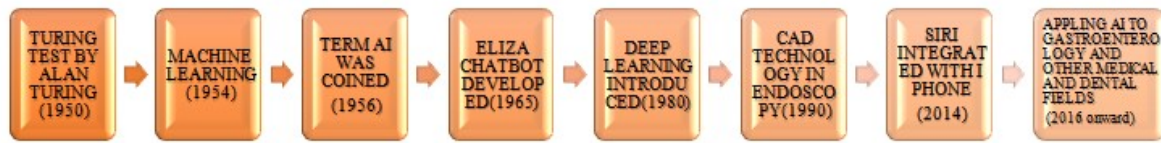
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## I. HISTORY OF ARTIFICIAL INTELLIGENCE



**Figure 1**

AI has become a rage these days, but it is not a “new” concept. The first computer that could think for itself has been around since 1950. Later, Alan Turing tried to discover the concept of machine intelligence in the years after WWII. He penned down 36 pages about computer intellect in a paper named “Computing Machinery and Intelligence”.<sup>1</sup> John McCarthy coined the term “Artificial Intelligence” six years later. He came up with the very first programming language - language symbolic computation. These theories laid the foundation of all the technologies that were invented in the coming years.<sup>2</sup>

Dental AI was first implemented in prosthodontics. In the 1990s, scientists prepared computer-based models of human teeth by using Computer Aided Models (CAM). It could engineer 3D models of dental crowns according to the patient’s preferences only by checking their remaining dentition. The dentists could print out these models and it eased the manual process of casting prostheses.

The Journal of Dental Research Study revealed that the CNN AI model could accurately classify caries. The model checked 2417 single-tooth radiographs and identified the decay correctly in 92.5% of the cases. In 2007, machine learning was used to analyze dental radiographs and images to detect tooth decay. Once the computers were trained on enough datasets, they could easily read radiographs and diagnose the defects just like humans. Following these studies, machine learning algorithms have gained immense momentum. They are now able to analyze X-rays and CBCT, identify periodontal problems, predict treatment prognosis, and detect oral cancers. (Figure 1)

Robert Faellia, the Founder of ADA has rightly said: “Dentists are radiologists, surgeons, business people, marketing people, and more. If AI can help them do all this better, there’s so much potential for space.” Intelligent computers have made modern dental practices much more effective as they streamline various phases of patient care. AI-driven tools are much more accurate and efficient in comparison to humans. They can work tirelessly throughout the day without any rest or getting bored. Even complex radiographs can be figured out in a jiffy by using AI. The bottom line is that AI has significantly mitigated the possibility of false diagnoses and dissatisfied patients. With that said, let’s discuss the most prominent ways in which AI is used in different fields of dentistry.

## II. CONSERVATIVE DENTISTRY AND ENDODONTICS



**Figure 2**

Dental caries is one of the most prevalent conditions that commonly affects children and young adults. Early detection and quick dental intervention can help ensure the longevity of teeth while preventing their loss. There was a time when dentists used a microscope to detect dental caries. More often than not, this process was not too accurate as it missed out on hidden surfaces of teeth. Consequently, the infection went unnoticed. With the advent of AI and computer-aided detection (CAD) tools, it is possible to identify carious lesions just by looking at photographs. In comparison to the naked eye, AI technology checks the radiographs at a pixel level which makes it easier to detect tooth decay. It saves the time and resources taken to arrive at a correct diagnosis.<sup>3</sup>

CAD software is programmed to read dental radiographs and reports obtained through CBCT and MRI. It eliminates the need for painful dental visits by highlighting potential cavities, bone loss areas, tooth fractures, and other pathological conditions that can be overlooked during manual examination. (FIGURE II)<sup>4</sup>

## III. ORAL AND MAXILLOFACIAL PATHOLOGY

With the help of AI predictive tools, it is possible to determine whether an oral lesion has the potential to grow cancerous. Machine learning has made it easier to classify different diseases and predict their course. According to recent research, dental professionals took 23 minutes to recognize cancers with 81% accuracy while AI gave similar results in hardly 38.7 seconds. So, it is evident that machine learning algorithms can be a powerful diagnostic tool in clinical practice. (Figure 3)

Nayak et al. (2005) used ANN (Artificial Neural Network) to differentiate between normal, premalignant, and malignant tissues with the help of laser-induced auto-fluorescence spectra recordings. It showed an accuracy of 98.3%, a specificity of 100%, and a sensitivity

of 96.5%. Uthoff et al. (2017) used CNN (Convolutional Neural Network) autofluorescence images and white light images to detect precancerous and cancerous lesions. It proved to be more effective than ANN. Aubreville et al. (2017) took to DL (Deep Learning) to recognize oral cancer based on confocal laser endomicroscopy. Shams et al. (2017) carried out a comparative study to predict the course of potentially-malignant oral lesions to oral cancer with the help of DNN (Deep Neural Networks). This technology was much more accurate when compared to vector machines, regularized least squares, and multilayer perception.<sup>5</sup> Besides such cancerous lesions, AI can also be used to detect salivary gland disorders, TMJ problems, sinus abnormalities, and bone disorders like osteoporosis.<sup>5</sup>



**Figure 3**

#### **IV. ORTHODONTICS**

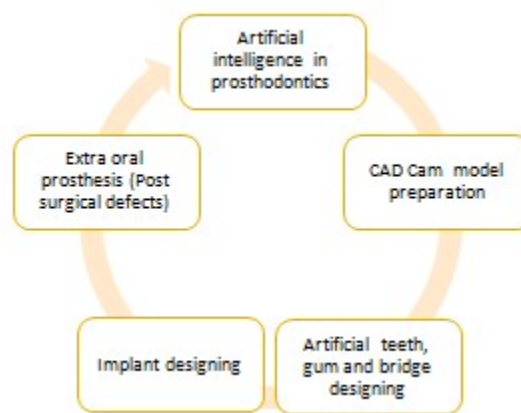
Machine learning software has the capability of interpreting cephalometric and panoramic radiographs. It is equipped to perceive mal aligned teeth and jaw abnormalities through radiographs. Advances in AI have empowered orthodontists to engineer precise and customized braces and aligners that ensure a better prognosis with faster correction of the tooth alignment.<sup>6</sup>

Most patients dread orthodontic treatments as it involves long dental visits with multiple follow-ups. However, a novel approach called Dental Monitoring Tools has allowed doctors to monitor the treatment progress remotely. So, you don't have to visit the dentist now and then for follow-up. Instead, the doctor will be able to examine your teeth through a

virtual examination. The doctor can even figure out poor periodontal condition and oral hygiene in this examination.

## V. PROSTHODONTICS

As mentioned previously, dentists can now create custom-made prostheses with the help of CAM/CAD models. These models are aligned with the patient's requirements and their ethnicity and facial features. The software calculates the size and shape of artificial teeth, gums, and bridges that need to be printed out. (Figure 4) The advantage of these AI models is that it eliminates the need for manual casting, thereby reducing the human error rate by around 100%. Dentists can prepare well-fitting prostheses and deliver them to patients without any delay after approval from seniors.



**Figure 4**

## VI. PERIODONTICS

Ozden et al. (2015) examined the use of a support vector machine (SVM), decision tree (DT), and ANN to identify and classify periodontal disease. Gene analysis of the amplified 16s rRNA from the patient's saliva, malodor, and healthy breath (Nakano, Y.2018), the occurrence of recurrent aphthous ulcers was determined with the help of artificial neural work (ANN) algorithm and peri-implant condition and periodontal bone loss with the help of deep neural network (DNN) of ML by periapical radiographs. (Danks et al. 2021).<sup>5</sup>

## VII. PEDODONTICS

AI in paediatric dentistry is used to assess children's oral health. It also helps in identifying mesiodens and supernumerary teeth. Some researchers have also made use of ANN (Artificial Neural Networks) to predict the presence of dental caries based on polymorphisms. The data from these predictions could aid in the prevention of caries in children by implementing suitable treatment plans and early intervention.<sup>7</sup>

1. Dental plaque
2. Early childhood caries
3. Mesiodens and supernumerary teeth identification
4. Ectopic eruption

5. Chronological age Assessment
6. Identification of deciduous and permanent teeth

### **VIII. ORAL MEDICINE AND RADIOLOGY**

ANNs are used to interpret plain radiographs, ultrasound, computed tomography, magnetic resonance imaging, Cone Beam CT, and radioisotope scans. With the help of ANN, a computer can accurately generalize a setting by tuning the parameters within the algorithm to optimize the goodness of fit between the input and output. For instance, an ML algorithm can diagnose a dentoalveolar pathology in case it is done by a professional radiologist by evaluating thousands of similar images labelled as normal or abnormal.<sup>8</sup>

### **IX. ORAL SURGERY**

ANN can be used to detect nasal bones as it can quickly recognize the interdependence between the nasal bone and facial landmarks. CNN and R-CNN help in predicting fractures which aid in early diagnosis and proper execution of the surgery. Chinski et al. used perioperative photographs and created an AI model that accurately emulated rhinoplasty surgery outcomes. AI enables the creation of a detailed plan for orthognathic surgery. In addition, AI models help in the prediction of perioperative blood loss, systemic infections after orthognathic surgery, and the future need for surgery.

However, although AI has great potential for OMF cosmetic surgeries, it involves several ethical concerns. It can lead to discrimination of ethnicity and gender which can marginalize other cultures' values and definition of beauty. Because of these limitations, dental professionals should make sure that a biased approach does not hamper decision-making.<sup>9</sup>

### **X. ADVANTAGES AND DISADVANTAGES OF ARTIFICIAL INTELLIGENCE**

<b>Advantages</b>	<b>Disadvantages</b>
Accuracy and efficiency	High cost
Powerful Diagnostic Tool	Unemployment
Always Available	Human Dependent

### **XI. ETHICAL AND LEGAL THOUGHTS IN AI**

1. Inspection Transparency
2. Accuracy
3. Confidentiality
4. Government Authority
5. Regulation
6. Privacy
7. Mitigation of bias

### **XII. FUTURE OF DENTAL AI: SHOULD YOU BE WORRIED ABOUT YOUR JOB?**

Artificial intelligence has certainly modernized the way dentists operate. It is much better than humans in so many aspects. However, AI can never replace human touch, empathy, creativity, and the skill of hands. Dentistry is a psychomotor craft that requires years of hands-on training and hard work. So, while AI-powered tools are making things easier for dental practitioners, they don't have to compete with humans.<sup>2</sup>

Moreover, a survey report has revealed that most patients were skeptical about robotic hands being put inside their mouths. Some others also said that they could not trust computers with their health. Having said that, if you are a dentist, rest assured that your job is still secure and you just need to stay abreast with "how to use AI-powered tools" rather than worrying about being replaced.

AI has its intellectual challenges and requires combined basic research in cognition, statistics, algorithms, linguistics, neurosciences, and much more.

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