

# AN INSIGHT INTO ARTIFICIAL INTELLIGENCE AND EMERGING TECHNOLOGIES IN DENTISTRY

## Abstract

The field of dentistry, like many other sectors, is experiencing a transformation from emerging technologies, notably artificial intelligence (AI). This paper provides an overview of AI and other cutting-edge technologies currently influencing dentistry. AI has found applications in diagnosis, decision-making, and treatment planning in oral radiology, orthodontics, periodontics, and surgical procedures. In addition to AI, other technologies such as intraoral scanners, CAD-CAM systems, 3D printing, CRISPR gene editing, teledentistry, virtual reality, imaging techniques, Diagnodent, and dental lasers are shaping the landscape of dental practice. These technologies promise improved efficiency and enhanced patient care. However, challenges related to cost and implementation remain. Training for clinicians and staff to effectively utilize these technologies is imperative for their successful integration into dental practice. Overall, it is evident that AI and emerging technologies are poised to revolutionize the field of dentistry, offering innovative solutions to existing challenges and paving the way for the future of dental care.

**Keywords:** Artificial Intelligence, emerging technologies.

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Technology is leading the world in current times and has penetrated every field easing people's lives. Technology is revolutionizing healthcare and the way medicine is practiced. Likewise, dentistry is influenced and benefited by current technologies including artificial intelligence. Technology means the practical and industrial use of scientific discoveries.<sup>1</sup> Technology introduces means and methods that make the job easier manifold, save time, and be cost-effective, thus making the lives of patients and healthcare providers much easy and more comfortable. Artificial intelligence (AI) is an emerging technology in healthcare and has given much more emphasis to the role it plays in diagnosis, decision-making, and treatment. Artificial intelligence is computer systems that mimic human intelligence and perform tasks that normally require human intelligence.

Current and emerging technologies in dentistry are artificial intelligence, intraoral scanners, CAD-CAM, imaging techniques, virtual reality, teledentistry, 3D printing, etc. This chapter summarizes these technologies that are impacting dentistry.

## I. ARTIFICIAL INTELLIGENCE IN DENTISTRY

The history of artificial intelligence started with the Turing test introduced by Alan Turing in 1950, if a machine can trick a human being into thinking that it's human, then the machine is said to be intelligent. Since then, AI has been successfully experimented with in various domains, including medicine and a little later dentistry. AI plays a main role in diagnosis and decision-making in dentistry. In oral radiology, AI has been used in the diagnosis of dental caries, sinusitis, osteoporosis, risk assessment of oral cancer, implant planning, implant detection, detecting and classifying odontogenic cysts, and tumours from intraoral radiographs. AI is also used in differential diagnosis, differentiating ameloblastoma, odontogenic keratocyst, and metastasis from non-metastatic carcinoma from computed tomography (CT) images. AI has also been used in the staging of oral cancer which helps in preventive measures to avoid the progression of the disease.<sup>2,3</sup> Early diagnosis plays a huge role in preventive dentistry and patient education programs. To achieve these diagnoses convolutional neural networks that are a deep learning method are implemented and the algorithms are trained with radiographic images.

Deep learning a subset of AI, is capable of assessing the need for orthodontic extraction. Automatic customized tracing and cephalometric analysis with AI technology help in planning orthodontic treatment, AI can also help in treatment outcome analysis. AI-based orthodontic monitoring will allow orthodontists to evaluate the progress of treatment from afar through patient phones and unique tools.<sup>4</sup> Invisible aligners in orthodontics are a revolutionary alternative to conventional metal brackets and have changed the way malocclusion is treated. Invisalign has addressed the concerns of aesthetics, periodontal maintenance, discomfort, etc associated with metal brackets. Apart from comfort and aesthetics, Invisalign also reduces treatment duration, yet the cost and achieving precise occlusion is a concern.<sup>5,6</sup> Patient's virtual models i.e. impressions and records are shared with the laboratory. The orthodontist receives the patient's virtual 3-D models in which the treatment plan is furnished for tooth movements and the orthodontist can visualize virtual corrections of each stage and if any corrections are required can be suggested to the lab. Once the orthodontist approves, aligners are fabricated. The software produces a series of aligners that will correct malocclusion. This entire process is done through AI-based software.<sup>7</sup>

AI algorithms can accurately detect and interpret alveolar bone level and radiographic bone loss and can be a useful adjunct to periodontal diagnosis and treatment planning.<sup>8</sup> AI algorithms can predict and diagnose periodontally weak teeth and assess the need for tooth extraction. These AI algorithms can be a valuable adjunct in periodontal maintenance and preventive measures. AI is a useful tool in the virtual planning of surgeries in implant placement, reconstruction of facial defects, and orthognathic surgery. AI software will allow clinicians to virtually perform surgery and they can anticipate and predict the course and outcome of surgery.<sup>9</sup>

A dental inspection software (smart Margin and scan clarity, Pearl) can analyze intraoral scans and give feedback on prepared teeth. Laboratories can also use this software to assess the preparations. Smile designing software can assist in virtual planning, patient education, and outcome analysis. This AI software proposes tooth shape and alignment, this design can create a mock-up, preparation, or surgical guide.<sup>4</sup>

AI assists in the maintenance of dental records, and could also assess smoking status from electronic records. AI systems could assess and diagnose temporomandibular disorders. AI could predict patients' age from radiographs and facial reconstruction with machine learning is a valuable tool in forensic dentistry. AI helps in preventing fraud claims with dental insurance. It is expected in the near future dental clinics will adopt AI comprehensive care system, patients' histories and records managed by AI systems will also help to understand oral diseases better and improved patient care. AI will minimize human error by providing comprehensive feedback regarding patients' medical history, allergic history, disease, and drug interactions, overall improving treatment outcomes and patient care.<sup>4</sup>

## **II. INTRAORAL SCANNERS**

With the use of intraoral scanners, tedious impression and model preparation techniques are replaced saving clinician time and improving the accuracy of tissue registration. Intraoral scanners (IOS) digitally reproduce the 3-dimensional (3D) geometry of the intraoral tissues. scanners project a light source/laser on the surfaces being scanned and the sensors capture video or images, these images are processed by software to produce a 3D model. Multiple brands and generations of IOS systems and technologies are available, that can be chosen based on applications like orthodontics, restorations, fixed partial dentures, implant surgical guides, etc.<sup>10</sup>

### **1. CAD-CAM**

CAD-CAM stands for computer-aided design and computer-aided manufacturing. The system consists of three components, a scanner that transforms geometry into digital data, software that processes this data into a design/product, and a third manufacturing unit/milling machine that converts the design into a product. CAD-CAD unit can be chairside or at the laboratory. CAD-CAM restorations are fabricated by a subtractive technology that has superior properties.<sup>11</sup> These systems replace conventional tedious techniques of restoration, dentures, and prostheses fabrication, saving clinician time with added accuracy and patient satisfaction. Disadvantages associated with CAD-CAM systems are the associated expenses, the need for knowledge of technology and sensitive operations, maintenance, and the wastage of restorative material. Some of the currently available CAD-CAM systems are CEREC AC

(Sirona, Charlotte, NC, USA), E4D Dentist (D4D Technologies, Richardson, TX, USA), iTero (Cadent, Carlstadt, NJ, USA), and Lava COS (3M ESPE, St Paul, MN, USA). Davidowitz, G., & Kotick, P. G. (2011).<sup>12</sup>

## **2. 3D Printing**

3D printing is additive manufacturing technology introduced in 1986 by Charles Hull. It is a three-dimensional printing technology based on CAD models using standardized materials to create 3D objects in an automated process. The advantages of this technology include high precision and rapid production. There are three 3D printing technologies, powder bed fusion, light curing, and fused deposition modeling. In dentistry, this technology is used in fabricating crowns and bridges, dentures, splints, working models, and surgical implants and guides. 3D printing brings about a means of fabricating complex models with more efficiency, and less wastage of material. However, the system has challenges of high cost and knowledge of the operation. Yet this technology is going to override conventional means and be the future of dentistry.<sup>13</sup>

## **3. CRISPR**

This acronym stands for Clustered Regularly Interspaced Palindromic Repeats. CRISPR is a programmable protein that can edit, eliminate, and turn on/off the genome. One of the gene editing technologies with high efficiency and accuracy is promising in cancer therapy by introducing gene modifications in cell lines, organs, and animals. This technology is playing a vital role in preventive and predictive therapy in dentistry. Other applications in dentistry include the prevention of dental caries, dental plaque formation, treat salivary dysfunctions in Sjogren's syndrome, tooth and palate development, and TMJ disorders.<sup>14,15</sup>

## **4. Teledentistry**

Teledentistry is telehealth using a combination of dentistry and telecommunications, it involves the exchange of clinical information and relevant imaging over a remote distance for the purpose of consultation and treatment planning. For urgent dental care, it is encouraged to assess risk, triage, and manage remotely over a telephone or video to provide urgent dental care. This unique way of healthcare delivery brings ease of use, patient satisfaction, and increased access to dental services providing specialist care, minimizing time of work, and minimizing travel for consultations. This helps the dentist and patient to save time on the first visit and be well prepared for the second visit. This can be valuable in this digital era and hectic and busy lifestyle.<sup>16</sup> There are still certain issues to be addressed before teledentistry becomes a routine thing but can be of immense benefit to society with limited dentists and inaccessibility.

## **5. Virtual Reality**

Virtual reality is a computer-generated three-dimensional world in which the users interact with virtual objects. Augmented Reality is another technology that superimposes a computer-created virtual scenario over an existing reality to create a perception through the ability to interact with it. This can be made into applications in mobile devices to blend digital components into the real world in a way that they enhance each other. In dentistry, its

primarily used in the field of dental education from skill training in tooth preparation to complex maxillofacial rehabilitation approaches. This simulation exercise enhances student dexterity skills and the use of 3D vision in virtual learning improves the performance of the students. Other simulation exercises in dentistry include caries excavation, nerve block, reconstruction of facial defects, and learning 3D anatomy. This technology is also helpful in allaying dental anxiety especially in pediatric cases distracting them to reduce the emotional response.<sup>17</sup>

## 6. Imaging

Cone beam computed tomography (CBCT) imaging technique based on a cone-shaped X-ray beam centered on a 2-D detector. It does one rotation around the object and produces a series of 2-D images that are re-constructed into 3-D images. This technology was developed in 1984 by Aboudara et al.<sup>18</sup> CBCT is the new way of imaging in dentistry with reduced radiation dose, reduced exposure time, and compatibility with surgical, prosthetic, aesthetic, and orthodontic analysis and design software and it makes the ideal imaging technique in dentistry.<sup>19</sup> CBCT is used in oral surgery for surgical assessment and planning for impacted teeth, cysts, tumors, implant and orthognathic surgeries, and diagnosis of inflammatory conditions and fractures of the jaws and the sinuses. CBCT can be used in pre- and post-dental implant placement assessment.<sup>18</sup>

## 7. Diagnodent

Diagnodent is a state-of-the-art device used to detect early dental caries. It is a portable device that uses sound pulse and laser to detect caries earlier in comparison to conventional than traditional methods. The accuracy of detection being higher is helpful in early preventive measures.<sup>20</sup>

## 8. Dental Lasers

LASER means “Light Amplification by Stimulated Emission of Radiation” which generates electromagnetic radiation of uniform wavelength, producing coherent, monochromatic, intense, and collimated light.<sup>21</sup> Lasers have a wide array of uses in dentistry in periodontal surgeries, dental implants, caries prevention, caries removal, and cavity preparation, photobiomodulation (PBM) in dentistry, laser-supported endodontic treatments, fluorescence-supported oral cancer diagnosis, and treatment, lasers in wound healing, laser-driven biopsies. Lasers are being increasingly used in cancer healing and other domains of dentistry and are promised to be a reliable mode of treatment.<sup>22</sup>

## CONCLUSION

Artificial intelligence and other emerging technologies in dentistry are a boon to the field as they improve operator efficiency and improved patient care. Yet the cost and implementation are a concern. Clinicians and assistants need to be trained to adopt and use these technologies to the best. It appears that AI and technologies are going to be the future of medical and dental practice.

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