AI IN DENTISTRY- THE PAST, PRESENT AND FUTURE

Abstract

The integration of Artificial Intelligence (AI) has undeniably revolutionized dentistry, enhancing diagnostic accuracy, streamlining treatment planning, and transforming patient care. AI algorithms can now analyze medical images for precise diagnoses, suggest multiple personalized treatment plans, and predict oral health issues. This chapter intends to provide a comprehensive exploration of AI's evolution in dentistry, tracing its initial stages to its role in the present day and projecting its immense potential for the future.

Keywords: AI, Dentistry, cephalometric landmarks, orthognathic surgery

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I. INTRODUCTION

Artificial Intelligence (AI) can be defined as 'a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation.'[1] It is an area of computer science focusing on designing intelligent computer systems that demonstrate traits linked to human intellect, such as linguistic capability, learning, reasoning, problem solving ability, and much more.[2]

Over the past few decades, dentistry has undergone significant transformation with the integration of AI technology. From improving diagnostic accuracy to streamlining treatment planning, AI has played a pivotal role in revolutionizing dental practices. In this chapter, we will explore the journey of AI in dentistry, from its humble beginnings to the current state of affairs, and glimpse into the immense potential it holds for the future.

II. AI IN DENTISTRY- THE PAST

Although it's hard to say for sure, the beginnings of AI can presumably be dated back to the 1940s, when American science fiction author, Isaac Asimov wrote his short novel 'Runaround' featuring a humanoid robot built by engineers Gregory Powell and Mike Donavan. Asimov's novel encouraged generations of scientists to pursue research in robotics, artificial intelligence, and computer science. Shortly thereafter, British mathematician and computer scientist, Alan Turing's bizarre imagination, on whether machines were capable of thinking, resulted in the creation of the first working electro mechanical computer, which deciphered army codes. In his work, 'Computing Machinery and Intelligence,' he introduced the 'Turing Test', which is still employed as a benchmark to ascertain an artificial system's level of intelligence.[3-5]The term 'Artificial Intelligence' was officially coined by John Mc Carthyin 1956 along with Marvin Minsky, Nathaniel Rochester and Claude Shannon, at the Dartmouth Summer Research Project on Artificial Intelligence, in New Hampshire. Owing to the significant contribution to science, John McCarthy is widely considered as the father of artificial intelligence.[3]

The advent of AI in dentistry may have been inspired by the creation of the first electric brush (which attempted to mimic hand dexterity) way back in 1954 by Dr. Phillipe-Guy Woog. Though the prototype was originally designed as early as 1939, it was only marketed in 1960, by the name Broxodent.[6]With the introduction of the first CT scanners in the 1970s, more precise and detailed images of teeth and jaws could be captured, enabling better diagnosis and treatment plans.[7]However it was not until the late 80's that AI inspired Computer-aided models (CAM) were developed by Mormann & Brandstinni to create in-house ceramic restorations. CAM could create 3D dental crown models based on a patient's preference just by examining their remaining teeth.[7,8]The invention of the first computer controlled dental drill in 1971 meant that the precision and accuracy of dental procedures would improve with significant control over the drill's speed and direction. Later in the 1900's computer aided designing/computer aided manufacture (CAD/CAM) was developed that aided in 'single visit' manufacture of ceramic crowns and bridges using digital imaging. The first 3D printer for dental use was also developed in the same decade.[7]In 1999 the first Cone Beam CT machine for dental usage was launched in Europe.[9]

III. AI IN DENTISTRY-THE PRESENT

In the present day, AI has achieved substantial progress in the field of imaging and oral diagnostics. Machine learning algorithms, particularly deep learning, have demonstrated exceptional capabilities in recognizing dental conditions such as caries, periodontal diseases[10], and even oral cancers.[11] AI-powered systems can rapidly analyze vast amounts of radiographic and photographic data, assisting dentists in early and accurate disease detection. The integration of AI in RVG, CBCT and 3D printing has revolutionized the field of radiology.[10]AI can accurately detect and recognize anatomical structures while AI integrated tools can precisely differentiate and categorize teeth from radiographs with an accuracy of 95.8–99.45%.[12] Similarly AI can also be trained to efficiently detect caries[13], sinus pathologies, impactions, root fractures, bony lesions or oral mucosal lesions with significant speed and accuracy.

AI has also facilitated personalized treatment planning for dental patients. By analyzing a patient's dental history, medical records, and oral health data, AI algorithms can suggest tailored treatment options while assessing risks. These recommendations are not only based on evidence-based dentistry but also take into account individual factors like age, medical conditions, habits, genetic predisposition and lifestyle. It can also provide patient education and emergency teleassistance when required.[10]

In the field of Orthodontics, AI can effortlessly identify and analyze cephalometric landmarks, optimize tooth movement, plan tooth extraction, assess growth and development, and predict the need for an orthognathic surgery. It can also access age and determine cervical maturation.[14]AI-driven applications can provide patients with visualizations of their orthodontic treatment progress and outcomes, enhancing patient engagement and understanding. Furthermore by utilizing 3D scans and virtual models, clear aligners can be easily designed and 3D printed as per patient need. With AI integration, treatment time has greatly reduced while outcomes have become more predictable[10]

Prosthodontics is considered the launchpad of AI in dentistry. With the advent of CAD/CAM, prosthetic designing and delivery became a more simplified process.[7, 8, 9] Intraoral scanners can precisely create 3D impressions of the teeth and the gums, which would have otherwise required conventional impressions that rely on multiple factors. These can be further used to design and fabricate crowns or bridges, using the CAD/CAM system or create 3D prints to simulate implant placement prior to the actual procedure. CBCT scans of involved areas can aid in precise implant planning using dedicated softwares, which contain updated implant databases.[7] The AI design assistant 'RaPid' combines several anthropological parameters and patient preferences to create an ideal aesthetic prosthesis.[10]A patient's smile can now be customized with 'digital smile designing', which involves the fabrication of a computer-generated 3D model of the teeth and gums, using digital imaging software. This technology can educate the patient and demonstrate the end result prior to the treatment.[15,16]AI algorithms could also measure masticatory efficiency and assist in differentiating various TMJ disorders.[16]

Identifying and quantifying alveolar bone loss was simplified with the advent of AI in Periodontics.[10]By employing deep learning algorithms on a series of radiographs, the

diagnostic accuracy of detecting periodontally compromised teeth greatly improved. AI models could differentiate between chronic and aggressive periodontitis and accurately predict teeth indicated for extraction.[16]

Apart from caries detection and precisely accessing restoration margins, AI can easily determine root fractures and peripiacal lesions. In the field of Endodontics, AI is an indispensible asset and plays a huge role in determining the exact working length[17], accessing the difficulty level of the treatment, understanding root canal morphology, predicting dental pulp stem cell viability, locating accessory foramens and forecasting retreatment options.[10]

With the integration of AI in surgical procedures there has been noticeable improvement in procedural accuracy, safer tissue manipulation and reduction in operation time and post-extraction complications. Image guided surgeries and robotic surgeries have revolutionized surgical procedures to a great extent and reduced the need for resurgeries.[18]

AI enables large volumes of data to be easily stored and effectively utilized to design applications that can be effortlessly used in age and gender estimation, bite mark analysis and predicting cranial morphology. ‘Bioprinting’ of living cells and tissues is the most promising feature of AI in the field of forensic Odontology.[19]

Research suggests that artificial intelligence is being increasingly used in the detection of tumour and cancer by integration with radiographic, microscopic and ultrasonic images. AI also assists pathologists in diagnosing malignant and pre malignant lesions with ease. It can also distinguish between various types of tumours by utilizing different AI generated algorithms.[20]

In pediatric dentistry, AI has been beneficial in adopting injection-free practice by providing pain control with the aid of AI assisted devices. It has also been employed to differentiate deciduous and permanent teeth, and to identify supernumerary teeth. Other applications include chronological age assessment, identifying ectopic eruption, early orthodontic tooth movement, CAD/CAM restorations and detection of plaque and caries affected teeth.[21-22]

AI can be of great assistance in patient education and communication (interactive chatbots), appointment scheduling, inventory management, clinical documentation, insurance and other paperwork management, saving valuable time and finances. Apart from these, AI has been employed in medical and dental studies to develop virtual patients, to simulate actual diagnostic and surgical procedures.[10, 19, 23-24]

IV. AI IN DENTISTRY- THE FUTURE

Artificial Intelligence is all set to metamorphosize dentistry, and make dental treatment experience, pleasant and predictable. AI technology will facilitate researchers and clinicians to delve deeper and gain better understanding of multifactorial disorders. The collective data acquired, will help to improve the knowledge of challenging and poorly understood disease conditions.

Dentistry has witnessed the radical transformation of 'The basic dental chair', from a meagre, manually operated model, to the most modern, automated 'avatar', fully equipped with multiple sensors. Thanks to AI, it is being further upgraded to recognize voice commands, thus eliminating the need for the dentist to perform any manual tasks. In future, it wouldn't be surprising to find dental chairs that can keep track of the patient's vital signs, anxiety levels, and procedure duration, while reassuring the patient and alerting the operator for any variations.[25]

An AI supported comprehensive dental care system might come into place, where separate pre, inter and post appointment patient care will be handled by dedicated AI applications. The pre appointment system would evaluate patient history and previous treatment records and compare it with the present health condition. The AI would then generate more predictable treatment options based on pretrained algorithms, keeping in mind the patient's preferences and clinician's recommendations. Additionally, feedback would be gathered during the treatment, making human error minimal.[26]

The future of AI in dentistry promises to integrate virtual reality (VR) and augmented reality (AR) into dental education. These innovative technological advancements can revolutionize dental training by providing students with interactive and immersive learning experiences.[21-22] Dentists of the future might use AR glasses to overlay digital information onto real-world scenarios, improving their diagnostic and treatment abilities.

AI-powered intraoral devices similar to the modern day smart watches, could soon become commonplace in dental practice. These devices may continuously monitor patients' oral health, providing real-time feedback to both the patients and dentists. Such tools would enable early detection of dental issues and promote proactive oral care.

Artificial Intelligence has already made significant contributions in dentistry, streamlining diagnostics, treatment planning, and patient care. It has become an integral part of daily dental practice, further enhancing precision, efficiency, and patient outcomes. However, it is crucial to address the challenges and ethical considerations on AI incorporation, to warrant responsible and beneficial integration into dental healthcare.

Many dentists are skeptical about AI taking over their jobs. It must be understood that AI was created to make human work more manageable, rather than offering competition. AI can never replicate innate human traits and complex emotions like empathy, resourcefulness, and flexibility in decision making. AI integration helps the dentist in putting focus on more important jobs like providing quality treatment, while it manages mundane administrative procedures and paperwork. The future of AI in dentistry holds tremendous promise, and dental professionals must embrace these innovations to deliver the best possible care to their patients.

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