

Exploring artificial intelligence in dentistry

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Abstract

As the influence of artificial intelligence (AI) expands across digital landscapes, its integration into dentistry has become an increasingly important topic of discussion. Dental professionals and students alike may question how AI will shape the future of dental practice. This report examines the multifaceted role of AI within the dental field, focusing on its potential to enhance diagnostic accuracy, streamline treatment planning, enhance dental education and optimise patient management. Despite its advantages, the employment of AI in dentistry is not without challenges; ethical concerns regarding data protection and patient privacy are reviewed to underscore the importance of responsible AI use. By providing a detailed analysis of these aspects, this paper aims to offer a clear understanding of how AI is set to transform dental practices and education while addressing ethical considerations such as patient privacy and data security.

Abbreviations

AI - Artificial intelligence

CBCT – Cone Beam Computed Tomography

GDC – General Dental Council

GDPR – General data protection regulations

RCT – Root canal treatment

VR – Virtual reality

What is AI?

“Artificial intelligence is the new electricity.”

Andrew Ng, the co-founder and former head of Google Brain, encapsulates the potential of AI in this single sentence.¹ AI marks the beginning of a new world, a transformative entity across countless

domains; in the past 10 years alone, the number of AI companies in the UK has increased by a factor of six hundred.² Moreover, the recent launch of OpenAI's Chat GPT highlights the increasing prevalence of AI amongst the general population.

Artificial intelligence is the ability of computer programmes to carry out tasks that would typically require human intelligence. By using technology like machine learning, natural language processing and adaptive learning systems, AI can perform tasks like logical reasoning, problem-solving and learning.³

Current applications and benefits of AI in dentistry

Diagnostic tools

Dental radiographs (X-rays) are the primary source of diagnostic information in dentistry, with roughly 22 million taken annually in the UK.⁴ Radiographs enable dental clinicians to identify different anatomical and pathological structures that are not readily visible on clinical examination.⁵ The Faculty of General Dental Practice (UK) sets guidelines to ensure the standard of dental radiographs and ensure 'delivery of an accurate diagnosis.'⁶ Albeit effective and widely relied upon, dental radiographs can be limited by subjectivity and misinterpretation despite quality assuring legislation from Public Health England⁶ in line with Ionising Radiations Regulations 2017. This is corroborated by a study highlighting that one third of dental panoramic x-rays across 41 practices were deemed as 'unacceptable' quality.⁷ Fatigue and human error are amongst reasons why there may be minor discrepancies between clinicians regarding missed or inaccurate diagnoses.

AI technologies offer a solution to this: by using its extensive patient database including case studies, AI can assess radiographs to

provide a more precise and accurate diagnosis to supplement the clinician's judgment.⁸ In many cases, this technology has been shown to identify early-stage caries (the most prevalent dental disease, causing demineralisation of dental hard tissue), assess the extent of periodontal diseases, and even highlight potential cancers. AI can present this information in a clear, visual manner to highlight areas of concerns which clinicians can subsequently use to explain any diagnoses or treatments further without disengaging the patient.

Treatment planning: implant placement

Cone Beam Computed Tomography (CBCT) is a type of dental radiograph that is widely used for implant procedures. The process involves a rotational scan to produce 3D images of an individual's jaw and teeth; this radiograph can then be used to determine several things when planning an implant placement.⁹ For example, identification of the maxillary sinuses can help determine whether a sinus lift is needed or if extra caution should be taken to prevent perforation. Similarly, a CBCT scan may be used to highlight the density and height of alveolar bone which will aid in correct implant sizing, and by determining the location of the mental foramen, treatment can be planned to reduce the risk of inferior alveolar nerve damage.

This is where AI can come into play. AI can explore these images in further detail, corroborating anatomical structures and making them easier to identify. AI can even produce virtual treatment plans and simulate surgical placements. These advancements can assist clinicians to ensure precise and optimal implant placements, focusing on critical details like the placement angle.¹⁰ Thus, integration of AI not only improves diagnostic accuracy, but also plays a supporting role in strategic treatment planning.

Treatment planning: endodontics

Endodontics is a dental speciality that involves the pulp and tissues surrounding the roots of a tooth. The most common procedure in this field is known as root canal treatment (RCT) whereby infected pulp tissue is removed, and root canals are obturated with filling material like Gutta Percha.¹¹ One of the challenges that dentists face when carrying out this procedure is accessing the root canal system.¹⁰ Genetic variation within patients may present as complex and irregular root canal systems; this may make the canals harder to access and increase susceptibility of re-infection post treatment.¹¹ Similarly, factors such as trauma and ageing may lead to intracanal hard tissue formations like pulp stones and tertiary dentine.¹² As a result, treatment may be complicated, often requiring extensive debridement and the use of specialist instruments.

AI-based software can be utilised to automate root canal detection by analysing radiographs; this helps dentists to locate complicated canal systems more precisely and efficiently.¹³ Furthermore, AI can consider anatomical structures and irregularities, enabling dentists to enhance their treatment plans by recommending specific instrumentation techniques. For example, this includes optimising the types of rotary files to use to appropriately shape and irrigate irregularly shaped canals.¹⁰ AI even encourages patient transparency by providing tailored success rates so that patients can make well-informed decisions about their care.¹³

AI in patient and practice management

Outside of treatment planning, AI can improve administrative tasks that are essential for the smooth operation of a dental practice. Over 18 million adults and 6 million children were seen by an NHS dentist over the past two years.¹⁴ The demand for dental appointments is high and the lingering repercussions of COVID-19 continue to affect clinical capacity and patient access.

To be able to manage logistics and administration effectively, AI algorithms can schedule dental appointments individually tailored

to the availability and preferences all of parties. It does this through analysis of extensive patient databases and practice data through natural language processing tools, which is the mode that allows digital devices to recognise, understand and generate text and speech.¹⁰ Additionally, AI can send out automated appointment reminders to patients to encourage and increase attendance rates. A literature review examined the success of AI-generated text reminders across healthcare practices, showing 86% of studies reported a decrease in missed appointments as a result.¹⁵ Dental practices can also manage their time more effectively and reduce waste by using AI to undertake tedious tasks like stocktakes and ordering.¹⁰

AI in dental education

The dental field is pioneering with the use of AI through virtual reality (VR) to enhance dental education.¹⁶ By wearing a VR headset, students can immerse themselves in a range of clinical scenarios, from patient history taking to observing oral and maxillofacial surgery. Studies have shown that this teaching method can help students build confidence and fine tune interpersonal skills like empathy and communication to implement in real life situations. VR-based teaching has enabled more efficient tooth preparations for restorative fillings and crowns and an improved quality of implant placements, highlighted by an extensive systematic review.¹⁷ This learning style is most effective when integrated with traditional dental teaching methods and has the scope to promote a safe learning environment to protect patients in the long term.

AI can also be advantageous to dental students when used as a personalised tutoring platform.¹⁰ Advancements in AI technologies means that it is indiscriminate of ability, preferences, and individual needs; AI is accessible to anyone who wants to enhance their learning.¹⁸ Students can compile copious amounts of learning material and suggested reading lists to streamline their studies simply by inputting data and specific prompts. Reflective practice is also encouraged as AI can produce personalised feedback and highlight areas of improvement for dental students to take on board. Educators can also use this tool to monitor their students' progress and provide timely support sessions.¹⁰

Limitations of AI

Despite the plethora of positivity and adaptation that AI brings to dentistry, we need to be mindful of the challenges and limitations that it poses. The main ethical concern that AI raises is data protection. The General Dental Council (GDC) mandates that all registered professionals must: "Maintain and Protect Patients information" as part of their nine standards.¹⁹ Similarly, the General Data Protection Regulations Act (GDPR) 2018 emphasises the necessity to handle patient data securely and fairly.²⁰

AI will utilise extensive datasets like medical histories, dental histories, patient details and case studies to analyse radiographs and provide treatment plans to achieve the outcomes mentioned. It should be stressed that clinicians using AI technologies are aware of the risks involved with AI data breaches and understand how to use data responsibly. Transparency with the patient is imperative. Individuals must be informed on how their data will be used and the risks that may arise. This is essential to obtain valid consent and maintain a level of trust and rapport.

Conclusion

It raises no doubt that AI possesses the ability to enhance patient care and satisfaction within dentistry by allowing dental professionals to work more effectively. AI has already made a lasting impact and the future is promising. It can be argued that AI is making significant advancements in the diagnostic aspect of dentistry, shifting the focus towards a more preventive and minimally invasive approach. As many more dental practices and schools look to implement AI, it is

pertinent to be cautious and ensure that the patient's best interests and protection remain at the heart of dentistry. Dental students must keep up to date on advancements within AI as these developments will undoubtedly influence their education and future practice.

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Hi, my name is Minha Chowdhury, and I am a second-year dental student at Peninsula Dental School. Writing this article on artificial intelligence and its potential applications in dentistry has been an exciting experience. I hope you find it as enjoyable and interesting to read as I did to write!

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