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The rise of **artificial intelligence** in dentistry: **A game changer** in patient care

In a twist that was once confined to the realm of science fiction, artificial intelligence (AI) has become the major topic in politics, business and the media. As a founder of two dental AI health companies—US-based VideaHealth and dentalXr.ai Europe-based—I am confident in saying that my initial vision and collaboration with entrepreneurs and researchers has helped shape the dental AI environment. I am privileged to have been part of the initial research in 2016 on apical lesion detection conducted at Charité—Universitätsmedizin Berlin in Germany, the Massachusetts Institute of Technology and the Harvard University in the US. The promising findings underscored a future where AI would redefine the very fabric of how dental practitioners approach diagnostics.¹

Since then, there has been a surge in AI-related publications in dentistry, particularly in the last five years.²⁻⁷ Radiographic image analysis is a focal point, and researchers globally have developed AI models to support dentists in diagnosing various dental images. The additional advantages of AI in dentistry include:

- streamlined detection of anatomical structures and dental materials, providing dentists with comprehensive preliminary findings, saving time and improving documentation quality;
- superior pathology detection, identifying conditions like early caries more accurately;
- enhanced patient communication, providing patients with a better understanding of their conditions by visually highlighting pathologies; and
- improved marketing potential, conveying the dental practice's commitment to progress, innovation and a patient-centric approach.

AI-driven software, has become a symbol of progress and sophistication for dental practices. The adoption of AI not only streamlines workflows and enhances diag-

nostic capabilities but also positions dental practices as pioneers in embracing the future of healthcare.

Beyond image analysis, dentists envision AI assisting in automating various processes in their practices, from generating insurance claims to transforming 3D scanners into diagnostic tools. AI has become intertwined with 3D-printing technology, heralding an era where precision meets efficiency, a future where dental prostheses and implants are not only tailor-made for each patient but are also crafted with unparalleled accuracy, thanks to the guiding intelligence of AI algorithms. As dental practices increasingly embrace this revolutionary amalgamation, the realm of AI and 3D printing in dentistry emerges as a beacon of innovation, promising a future where smiles are crafted with unprecedented precision and care.

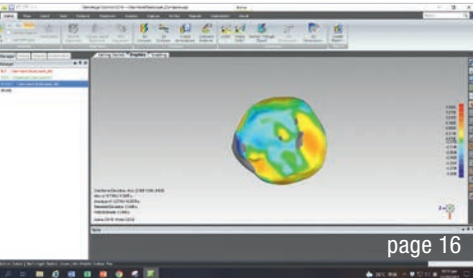
Despite concerns about AI replacing human roles, regulatory restrictions ensure that AI can only assist, the ultimate decision resting in human hands. While current AI capabilities may not generally surpass those of dentists, it is acknowledged that improvements will come with time and evolving algorithms. The future holds a vision where AI, combined with diverse image modalities and patient information, provides dentists with a comprehensive analysis of each patient and an individualised and maximally optimised approach to patient treatment.

As the dental community navigates the integration of AI into daily workflows, understanding how to harness its potential is crucial. The consensus is clear: AI is not a threat but a tool that, when utilised effectively, has the potential to revolutionise patient care in dentistry. The journey towards an AI-assisted future in dentistry has begun, and its impact promises to be transformative.

Editorial note: A list of references is available from the publisher.



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¹ not in all countries available yet.





Deep learning models can tackle massive amounts of information and learn the distinctive characteristics of specific types of documents to produce new, original work that is similar but not identical to the examples they have encountered.

The transformative power of AI in dentistry

By Eric Kukucka, Canada

Introduction

When we think of artificial intelligence (AI), our minds often conjure up images of sentient humanoid robots from iconic science fiction films like *2001: A Space Odyssey* and *Blade Runner*. More recently, films like *Her* have explored the concept of AI agents possessing consciousness. However, today's discussion delves into the use of AI in dentistry, where practical applications are changing the landscape of oral healthcare.

Defining AI in dentistry

Before we dive deeper into the profound impacts of AI in dentistry, let us establish a working definition. In practical terms, AI is a field of computing in which advanced

algorithms access extensive data sets to solve problems in ways reminiscent of human cognition. IBM aptly characterises AI as the utilisation of computers and machines to emulate human problem-solving and decision-making capabilities.

AI in everyday life

Many people are unaware that they interact with AI on a daily basis. If you have ever used voice-activated virtual assistants such as Apple's Siri, Amazon's Alexa or Google Assistant or received personalised recommendations on platforms like Netflix, YouTube or Spotify, you have already experienced the influence of AI. Beyond these personal interactions, AI plays a pivotal role in various aspects of our professional lives.

For instance, AI is the driving force behind automated speech recognition and closed captioning, enhancing accessibility for individuals with hearing impairments. In the realm of online customer service, AI-powered chatbots efficiently assist users on e-commerce websites, making shopping experiences smoother and more efficient. Moreover, AI excels in image categorisation and analysis, a capability we often encounter in apps like Apple Photos or during medical image assessments at healthcare facilities.

The evolution of AI

The recent surge in AI's prominence can be attributed to several factors. One crucial factor is the exponential growth in computational power, computers continuously becoming more potent and capable of handling complex AI tasks. Another pivotal development is the unprecedented access to massive data sets, consisting of millions of documents and images. Additionally, the emergence of deep learning networks has revolutionised AI by allowing it to process vast amounts of information, often derived from extensive online data sources.

Traditionally, software developers created specific algorithms tailored to solving well-defined problems. However, deep learning, a subset of machine learning, which is itself a subset of AI, introduced a dynamic approach. Deep learning models are adept at handling substantial data sets and can learn the unique characteristics of various document types, such as images, essays or strings of computer code. These models then generate new, original content that closely resembles the examples they have encountered, all with minimal human intervention.

Dr Rune Fisker, senior vice president of product strategy at the dental scanning and software company 3Shape, has underscored the significance of deep learning in AI's advancement. He noted that deep learning demands less development effort compared with traditional approaches while delivering significantly higher performance. The societal and other implications of this are profound, as it will make computers considerably more intelligent.

The implications for dentistry

But what does this mean for the field of dentistry? The potential applications of AI in dentistry are vast and transformative. While AI is not a panacea, ignoring its potential would be a missed opportunity. AI is poised to become the next evolution in the dental profession, much like how digital technology revolutionised dentistry by surpassing the limitations of analogue methods.

In our everyday lives, AI enhances our efficiency, effectiveness and predictability. In North American oral healthcare, these qualities translate into increased profit margins.



AI 2.0 (3Shape) edentulous scan.

Dr Fisker envisions AI-powered (computer-aided) denture design as not only technically feasible but also inevitable. The impact of AI extends to various aspects of dental care, including imaging, diagnostics and eventually design.

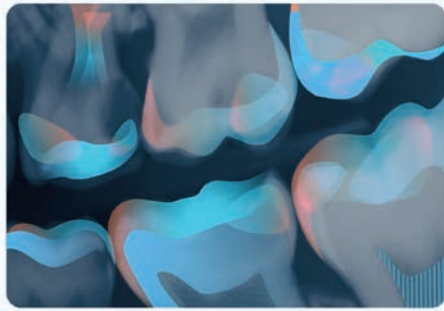
3Shape's current intra-oral scanning technology, called AI 2.0, uses AI to help identify edentulous soft tissue and delineate between soft tissue, teeth and other artefacts in the mouth. Conventional intra-oral scans naturally capture everything within range of the scanner's beam, including unhelpful images of soft tissue irrelevant to the final diagnosis or design of the final prosthesis. Using AI and deep learning, modern 3Shape scanners can intelligently differentiate between soft tissue and other, more important, intra-oral information. 3Shape's scanning software automatically and instantly deletes this soft-tissue information, producing a cleaner, more useful final digital record of a patient's intra-oral situation.

Before the company's AI-powered technology was developed, technicians and clinicians needed to manually annotate the unwanted soft tissue and tongue on the initial scanning output. Over time, 3Shape accumulated a very large set of these accurately annotated scans, which it then used to train its deep learning algorithm, effectively teaching it to do the identification work human annotators had performed previously.

AI in dental imaging and diagnostics

One of the most promising applications of AI in dentistry is in dental imaging and diagnostics. Traditional dental radiographs

The future
of dentistry,
powered by
AI.



AI-powered Second Opinion software (Pearl; hellopearl.com).

have long been indispensable tools for diagnosis and treatment planning. However, AI is poised to take this essential aspect of dental care to new heights.

Several companies are currently developing AI tools capable of automatically detecting dental conditions by analysing dental radiographs. Pearl, an American company, gained clearance from the US Food and Drug Administration for its groundbreaking software in this area. Pearl's AI-powered Second Opinion software has surpassed human accuracy in detecting signs of pathologies and common dental conditions in radiographs. It even excels at identifying issues that may be challenging for human dentists, such as incipient caries or early signs of periapical radiolucency. Pearl's approach is akin to providing dentists with a second set of eyes. This paradigm shift in dental diagnostics augments the capabilities of dental professionals, offering them invaluable insights that may have been overlooked owing to human fatigue or error.

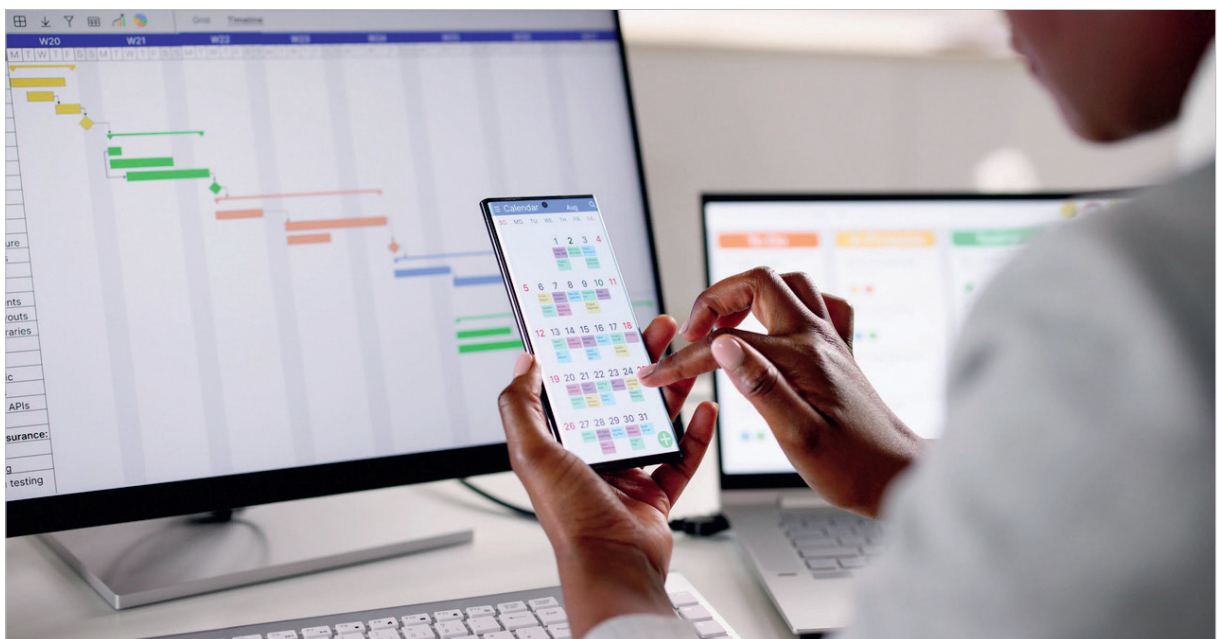
Enhancing patient care and efficiency

AI's influence extends beyond diagnostics; it has the potential to optimise patient care and streamline dental practices. Efficient patient scheduling is vital for maximising chair time utilisation, reducing patient waiting times and optimising resource allocation. AI can determine optimal staffing levels based on expected patient loads, minimising over- or understaffing issues. It can analyse patient histories to schedule appointments effectively, ensuring that facilities are neither under-utilised nor overbooked. Algorithms can calculate appointment duration, accommodate patient preferences for appointment times and healthcare providers, monitor real-time patient flow and adjust appointment schedules accordingly. Moreover, AI can send automated reminders to patients, enabling them to reschedule or cancel appointments online, thereby reducing no-shows. By historically predicting which patients are more likely to miss appointments, facilities can proactively overbook or send reminders to improve attendance rates.

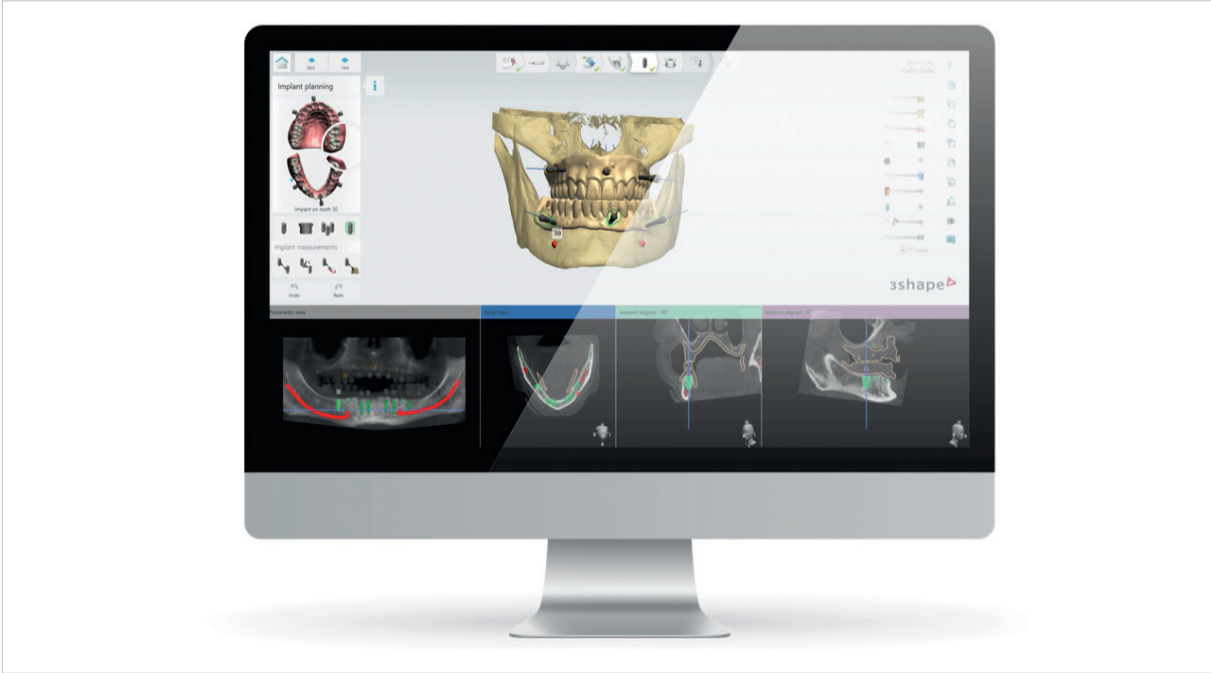
The future of AI in dentistry

The future of AI in dentistry holds immense promise. AI will be seamlessly integrated into practice management software, providing second opinions and aiding in treatment planning. Advancements in CBCT technology will offer unparalleled insights into anatomical structures, improving surgical interventions and implant placement.

Furthermore, AI will revolutionise the design of digital dentures, automating processes that were once performed manually. Currently, CAD technicians manually mark char-



AI can be used to improve patient scheduling software.



AI can assist in the design of surgical guides for implant placement.

acteristic points and the outer boundaries of dentures. With AI, these processes can be automated using deep learning and extensive data sets. While this intervention may not revolutionise dentistry, it will significantly reduce the time required in denture laboratories, making the design process more efficient.

Dr Fisker envisions a future in which patients can instantly view accurately generated digital simulations of their final dentures and laboratories can produce 3D-printed dentures within hours. In this future, AI will substantially reduce barriers to access, enhancing the patient experience. This outcome is not just theoretically feasible; it is highly likely to become a reality in the foreseeable future.

The role of AI in denture design

To delve deeper into the potential of AI in denture design, it is crucial to understand the underlying principles. Mathematical equations and discrete anatomical landmarks already exist to delineate essential denture design factors such as tooth position, tooth size, tooth shape and gingival contours. AI has the potential to automate a significant portion of the design process by relying on established philosophies, principles, physics, anatomy and physiology that have been instrumental in dentistry for decades.

Conclusion

In conclusion, AI in dentistry empowers us to be more predictable, effective and precise in our practice. Rather

than completely automating our workflows, it is essential to leverage AI as a powerful tool while dedicating time to validating AI-generated recommendations. This approach not only saves time but also enhances the quality of patient care, ultimately improving the lives of both patients and dental professionals.

about



Eric Kukucka graduated with a diploma of denturism from George Brown College in Toronto in Canada. He is vice president of clinical removable prosthetics and design technologies at dental service organisation Aspen Dental Management, where he is responsible for the efficacy involved in the delivery of care concerning removable

prosthodontics. He is an active researcher, educator, author and key opinion leader who has helped develop protocols, processes and materials used by practising clinicians around the world.

In 2019, Kukucka became the 32nd person in the world to be certified as a global instructor of Dr Jiro Abe's Suction Effective Mandibular Complete Dentures methodology. He collaborated on the development of monolithic milled digital denture technology with Ivoclar and of intra-oral scanning strategies for digitising dentures. He co-developed the reference denture scanning strategy with 3Shape and in 2021 became the first dentist appointed to its global corporate advisory board. He is also a member of SprintRay's clinical advisory board and a faculty member of the Digital Dentistry Institute. Kukucka co-authored *The Digital Removable Metamorphosis* (Quintessence Publishing, 2024).