Acta Scientific Otolaryngology (ISSN: 2582-5550)

Volume 5 Issue 8 August 2023

Opinion

Era of AI in Dentistry: Utopia or Dystopia

Esha Singh*

Medical Associate, Mediception Science Pvt Ltd., India

***Corresponding Author:** Esha Singh, Medical Associate, Mediception Science Pvt Ltd., India.

Received: May 30, 2023

Published: July 28, 2023

The advent of Artificial Intelligence (AI) can be traced back to 1950 when Turing introduced the concept of mechanizing intelligence in his paper, computing machinery, and intelligence. As with any venture, the project faced fundamental limitations, like memory and funding. It took 5 years for John McCarthy and Marvin Minsky to introduce the first artificial intelligence program in 1956. However, the journey was not smooth for decades until the landmark highly publicized win of IBM's Deep Blue, a chess-playing computer program against the reigning world chess champion and grand master Gary Kasparov in 1997. This marked a milestone in the role of AI in decision-making programs. Since then, AI has been fruitful in several industries such as technology, banking, marketing, and entertainment [1].

Despite the remarkable results in engineering, medicine was slow to adopt AI. The first sponsored AI-based medical workshop was held at Rutgers University in 1975. One of the initial prototypes was the CASNET model for the glaucoma consultation program. In line with Siri and Alexa, Pharmabot was developed in 2015 to assist in educating pediatric patients and their parents regarding medications. Mandy, an automated patient intake process for primary care practice, was created in 2017. In the same year, Arterys became the first Food and Drug Administration (FDA) approved clinical cloud-based Deep Learning (DL) application in health care. DL can be applied to detect lesions, create differential diagnoses, and compose automated medical reports [2].

AI paved its way in the field of dentistry through technological advancements in prosthodontics. The computer-aided design (CAD)/computer-aided manufacturing (CAM), a fairly common laboratory procedure in the present-era dental practice, was introduced to dentistry by Mormann and Brandestinni in 1989. This technology was created to allow fabrication of well-adapted ceramic restorations in-office in less time, thereby completing multiple restorations in a single appointment. Nowadays, CAD/CAM technology is widely utilized across various areas of dentistry. CAD/CAM technology is superior to hand-fabricated ears and nasal prostheses, maxillofacial implants that simulate bony contours following trauma or tumor excision, and restoratives like inlays, onlays, crowns and bridges [3].

The application of AI certainly has an edge over traditional methodologies. It has successfully strengthened the gamut of dentistry from laboratory applications to clinical decision-making. Artificial neural networks (ANNs) have been employed to efficiently analyze various types of medical imaging, such as plain radiographs, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), Cone Beam CT, and radioisotope scans [4]. AI algorithms have been utilized to aid maxillofacial surgeons in diagnoses, making therapeutic decisions, planning preoperative procedures, and predicting and evaluating outcomes in oral and maxillofacial (OMF) cosmetic surgery [5].

AI models have demonstrated various applications in endodontics such as studying root canal system anatomy, detecting periapical lesions and root fractures, determining working length measurements, determining the viability of dental pulp stem cells, and predicting the success of retreatment procedures [6]. In the field of pedodontics, AI models are of great help at the individual

and community levels. AI is effective in identifying and categorizing children into risk groups, diagnosing early ectopic eruption, age assessment, etc. [7]. Utilizing AI for automated cephalometric landmark identification in orthodontics can help reduce workload and minimize human errors. Another application of AI is seen in automating case setups for indirect bracketing or producing aligners, providing additional efficiency and accuracy [8].

AI is definitely a well-structured, labour-saving, and powerful tool to have in the dental armamentarium. Nevertheless, AI is still in its nascent stage and as with any man-made technological tool, has critical limitations.

Currently, the application of AI in Orthodontics is primarily focused on supervised learning tasks such as recognizing objects or points [8]. Research has indicated that when it comes to cephalometric analysis, angles and lengths predicted by neural networks do not exhibit statistically significant differences compared to those calculated from manually plotted points [9]. This insubstantial performance of AI can be attributed to the learning model of AL machine learning (ML) with is based on learnings from human expertise. However, this makes AI far flung from evidence-based dentistry (EBD), which is considered the standard for dental professionals' decision-making. It is essential to align further research with the increasingly recognized gold standard for research and reporting [10].

Contrast to the general notion, AI based treatment is not devoid of complications. Preventing considerable root resorption is imperative in orthodontic treatment. Light continuous forces that allow clinical tooth movement along with reasonable healing of cementum is an effective preventive strategy. Treatment with Invisalign aligners has been reported to result in root resorption as with any orthodontic treatment [11]. Similarly, a single center study in 100 patients observed apical root resorption in an average 7.36 teeth per patient treated with aligners [12]. This tends to question the credibility and feasibility of AI in managing more complex cases where the probability of unseen and unanticipated complications is high.

Understanding a case requires multiple basic medical and clinical specialties to provide plausible explanations for imaging findings. Additionally, advanced imaging techniques call for specialists to detect anomalies, perform segmentation, and classify images [4]. Supervised training is widely acknowledged as a key approach to enhance the performance of Convolutional Neural Networks (CNNs). This process involves exposing the CNN to labeled images to define structures for segmentation. However, caution must be exercised to avoid over-training CNNs, as it can lead to errors caused by excessive recognition [10].

Considering the relatively early stage of AI implementation in healthcare, it is unsurprising to find significant heterogeneity in methodologies and reported outcomes. Nonetheless, there has been a notable increase in the number of research publications in this field over the past few decades, with a particularly rapid surge in AI-focused papers in the past two years [10]. This might doubt the reliability and inherent validity of these reports [7].

Numerous ethical considerations emerge when incorporating AI into OMF cosmetic surgeries. Ethical dilemmas arise from AI systems claiming to objectively classify attractiveness, as it may result in discrimination based on ethnicity and gender. There is a risk that AI, in isolation, could perpetuate racial division and diminish diversity in cosmetic surgeries. The rapid advancement of AI in the healthcare sector is driven by improved computing speed, exponential data production, and routine data collection. However, thorough clinical evaluation and ethical reflection are necessary to address concerns regarding data protection, diversity, and transparency [5].

As we talk about AI and its vast applications, we focus on the intelligence part and are bemused, but tend to overlook the artificial aspect. Regardless of the considerable benefits and highly reliable outcomes facilitated by AI advancements in recent years, it is crucial for healthcare professionals to prioritize their clinical judgment, acknowledge the associated responsibilities, and act as both a partner and evaluator of the technical assistance offered by the digital environment, rather than relying excessively on digital services. Establishing an international agreement on a gold standard to assess these tools would greatly assist in evaluating their utility. Currently, the data is insufficient to derive robust conclusions regarding the efficacy and usefulness of AI tools in the field of dentistry.

Advantages of AI	Limitations of AI
Can detect lesions, create differential diagnoses, and compose automated medical reports	Cephalometric analysis predicted by neural networks do not exhibit statistically significant differences compared manual calculations
Computer-aided design (CAD)/computer-aided manufacturing (CAM) has revolutionized the area of maxillofacial and oral prostheses	Machine learning (ML) is based on learnings from human expertise. However, this makes AI far flung from evidence-based dentistry (EBD), the gold standard for decision-making.
Significantly superior efficacy of artificial neural networks (ANNs) in diagnostic imaging	Need for supervised training, nevertheless, over-training CNNs must be avoided as it can lead to errors caused by excessive recognition.
Automating case setups for indirect bracketing or producing aligners, providing additional efficiency and accuracy	AI-based study results are heterogeneous; thus the reliability and inherent validity of these reports are dubious
Reduce workload and minimize human errors	Ethical considerations are a major setback. Moreover, AI lack of humanoid factor

Table 1

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