A Comprehensive Review of Artificial Intelligence- A Modern Era in Paediatric Dentistry

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Abstract

The field of Artificial Intelligence (AI) in pediatric dentistry is rapidly expanding. AI, also known as computerized reasoning, is revolutionizing the realm of technology with its rapid development. Artificial intelligence is defined as the computer's or a robot's emulation of human intelligence processes. In dentistry, AI is increasingly employed to assist dentists in diagnosing and treatment planning based on radiographic assessments. It has become a focal point of discussion among pediatric dentists due to its efficiency in the non-pharmacological management of children. This is achieved through the use of 4D goggles, animations, and virtual reality games in pediatric dental clinics and hospitals, as well as in regulating a child's behavior. These approaches can also be used to distract

children during local Anaesthesia administration and to implement painless injection techniques. AI has already proven to be a game-changer in general dentistry, where it is used to fabricate restorations through pre-programmed, software-installed computers. This breakthrough has paved the way for AI-driven manufacturing of restorations and orthodontic appliances in pediatric dentistry, thereby reducing the likelihood of human errors. In this way, AI significantly lightens the workload of pediatric dental specialists, enabling them to work more effectively with children.

Keywords: Artificial Intelligence, Computer reasoning, Paediatric dentist, Behavior management, Deep learning models, Machine learning.

Introduction

AI is considered an expanding field in all aspects of human life, also known as the Fourth Industrial Revolution, well-versed in emulating decision-making abilities and critical thinking, constantly evolving.[1] The definition of AI characterizes it as a field of science and engineering concerned with computationally understanding what is commonly referred to as intelligent behavior and creating artifacts that exhibit such behaviour.[2] In simpler terms, simulated intelligence is depicted as computer systems capable of performing tasks typically requiring human intelligence, including learning and problem-solving capacities limited to the human brain.[3,4]

Numerous scientists, including Alan Turing, have aimed to create machines replicating human abilities, by introducing the Turing test to assess their problem-solving capabilities.[5,6] Richard Bellman, in 1978, defined AI as automating activities associated with human cognitive skills. Today, AI encompasses machines emulating human mental abilities, necessitating an understanding of key aspects. The concept of AI emerged in 1943 and was coined by John McCarthy in 1956, with the idea centered around creating machines capable of replicating human tasks. In a broader sense, AI refers to machine algorithms that can reason and perform cognitive functions. In modern times, two major AI branches, machine learning (ML) and deep learning (DL), are used in medicine, involving the development of algorithms and statistical models to enhance cognition and understanding by training them on large datasets to identify and apply patterns for prediction and decision-making with new data.[7,8]

In dentistry, AI plays a major role beginning with appointment scheduling, electronic health records and computer-aided radiographic and pathological interpretations.[9] A recent systematic review reported that AI methods can make dental care smooth, practical, better and efficient for dentists. In paediatric dentistry, patient management happens to be the most challenging part to the dentist where the AI provides a helping hand.[10]

The application of AI in pediatric dentistry holds particular relevance, as it demands not only procedural skills but also effective behavior guidance abilities. Numerous innovations are being introduced in pediatric dentistry to aid in identifying patients' behavioral patterns, managing anxiety, handling data, conducting investigations, making diagnoses,

Developing treatment plans, predicting outcomes and educating children and parents. This technology benefits clinicians by enhancing the quality of patient care and streamlining complex protocols, ultimately delivering predictable results.[10]

This article aims to spotlight the diverse AI innovations in paediatric dentistry, while also considering possible future enhancements through robotics that could revolutionize traditional clinical practices.

Ethics in artificial intelligence

Dentists are obligated to adhere to ethical principles outlined in moral guidelines, emphasizing values like autonomy and fairness, both at an individual and societal level. Despite the transformative impact of AI in dentistry, ethical concerns arise, encompassing aspects such as transparency, equity, nonmaleficence, replicability, responsibility, and security.[11] The ongoing progress of AI brings unforeseen challenges in bioethical domains, including issues related to informed consent, privacy, confidentiality, anonymity, and security.[12] It is clear that the new generation of dentists must acquaint themselves with AI technology and its ethical and social implications, as the future of dentistry hinges on AI implementation, which has the potential to enhance the quality of the dentist-patient relationship.[13]

Artificial intelligence in paediatric dentistry

Artificial intelligence has emerged as a significant development in pediatric dentistry, aiding in disease diagnosis, treatment planning, data and clinical management, as well as patient care before, during, and after procedures.[5]

Diagnosis

In the area of diagnosis, AI helps the paediatric dentist by automatic interpretation of the dental radiographs, detecting the oral hard and soft tissue lesions. This greatly saves time of paediatric dentists enabling them to concentrate more towards patient management during radiograph acquisition and also at the same time provides accurate diagnosis which paves the way to more standardized treatment procedures.[14]

Radiographic interpretation

Various AI-based systems have been developed for 2D and 3D imaging, including Denti.Ai, Overjet, Pearl, Diagnostic, and Relu, capable of automatically detecting anatomical structures.[15] In 2021, Kilic MC's study showcased the effectiveness of the AI system CranioCatch in automatically detecting and numbering deciduous teeth on Orthopantomograms (OPGs) with high sensitivity and accuracy.[16] Moreover research highlighted the improvements of AI algorithms bring to Bone Age Assessment (BAA) by enhancing radiologist accuracy and reducing variability using Convolutional Neural Network (CNN). In the same year, Kim DW utilized AI algorithms to automatically determine the skeletal maturation stage of patients aged 6-18 years, with the inclusion of chronological age and sex in the algorithms, thereby optimizing orthodontic treatment planning for growing patients.[17]

Orthodontic purposes

Invisalign has introduced Invisalign First, a clear aligner treatment for children aged 7 to 10 years. These aligners are specifically designed to address a wide range of younger patients' concerns, replacing arch expanders and partial metal braces. They utilize the same scanning technology used for adults and teenagers, making the process more comfortable and less intrusive than traditional alginate impressions. In addition to providing early orthodontic correction, these aligners also help prevent the exacerbation of orthodontic issues once permanent teeth emerge. Digital impressions have a wide range of applications beyond Invisalign treatment, including scenarios like model analysis, as well as the design and fabrication of space maintainers.[18]

Prosthodontic purposes

A systematic review comparing traditional and advanced digital impression techniques in dentistry, concluded that digital impressions offer a viable alternative due to their shorter acquisition time and the patients' improved perception of them compared to conventional impressions.[19] In particular, intraoral scanners like True Definition (TRU), Primescan (PRI), and TRIOS 3 (TRI)

excel in capturing interdental areas, making these digital impressions valuable for various applications in the restorative, prosthetic, and orthodontic treatment of pediatric patients.[20]

In the context of prosthetics, achieving aesthetically pleasing, long-lasting results requires proper fit and patient satisfaction. Rapid Prototyping techniques (RP), also known as generative manufacturing techniques, have demonstrated their utility. A report exemplified the practical use of computer-aided design and manufacture (CAD/CAM) to create a zirconia crown for a decaying primary molar in a single appointment, showcasing the efficiency of CEREC SW 4.6 system.[21,22]

Restorative purposes

Early Childhood Caries (ECC), a widespread problem in toddlers and children globally, especially in developing nations affects children's physical and psychological well-being, with a study underscoring that ECC's impact extends beyond oral health, emphasizing the significance of early diagnosis for improved outcomes.[23,24] AI plays a role in educating parents and caregivers about ECC and its detrimental effects. A study proposed the use of mobile text messages for ECC education and in 2021, Xiao J introduced an AI caries prototype smartphone app that enables parents to actively seek therapy for ECC at an early, reversible stage by taking images of their child's teeth.[25] Additionally, AI, particularly CNN, has shown great promise in accurately and efficiently identifying early interproximal carious lesions in oral radiographs.[26]

Tele dentistry

In tele dentistry, the advent of AI-enabled video calls has become the preferred mode of communication for parents and caretakers, simplifying diagnosis for remote dental specialists. The SARS CoV-2 pandemic further boosted the popularity of tele-diagnosis, tele-

consultations, and tele-monitoring, with the introduction of mobile applications like LinguAPP and WhiteTeeth Mobile App aimed at improving patients' oral health during this period.[27]

Behavior management

Behavior management is integral part of pediatric dentistry as it plays a crucial role in treatment planning.[28] It has been suggested that tools like 4D goggles, Virtual Reality (VR) games, movies, and animations can effectively shape a child's behavior to meet the pedodontist's needs. Additionally, VR can create a powerful illusion, immersing the patient in a virtual world and stimulating their senses, contributing to a child's satisfaction both during and after dental procedures.[29]

Dental education

The use of AI in education has the potential to enhance knowledge sharing, reduce costs, and ease the workload of instructors. Augmented and virtual reality tools are essential for training pediatric dentists, with augmented reality aiding skill development and virtual reality providing immersive training environments for clinical procedures and behavior management. These simulators not only improve clinical efficiency but also offer precise education for dental students.[30]

Robotronics - the future for paediatric dentistry

The field of dentistry has seen significant advancements in artificial intelligence and robotics, notably in robotic dentistry, where they have evolved from handling administrative tasks to performing intricate procedures, thereby enhancing patient care. Robots are being employed in various oral and maxillofacial surgeries, bringing improvements in infection control, postoperative recovery, and a reduction in surgical complications. However, for broader applications, more

research and technological advancements are required in this field.[31]

Challenges of ai in pediatric dentistry

The utilization of children's private information in the initial stages of AI training is crucial for enhancing application performance. However, it raises concerns regarding the management and sharing of clinical data, as the application of AI in healthcare may pose privacy risks due to the potential sharing of information among algorithms during operation. Furthermore, AI systems challenge our legal framework in determining responsibility for errors, leaving questions about whether dentists, software technicians, or both could be held accountable based on legal considerations. This highlights the need for the legal system to develop a clear framework for assigning accountability.[32]

Conclusion

Dental professionals are both proud of and concerned about the ongoing digitalization in the field, as AI applications offer advantages that make the lives of pediatric dentists easier while raising ethical concerns. The future will reveal whether the promises of concrete AI applications will be fulfilled or if concerns regarding data security and management in healthcare, can be addressed in the upcoming decade.

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