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Smile Innovations: Exploring the Impact of Artificial Intelligence in Pediatric Dentistry: A Narrative Review

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Abstract:
Artificial Intelligence (AI) technologies play a significant role and significantly impact various sectors, including healthcare, engineering, sciences, and smart cities. AI has the potential to improve the quality of patient care and treatment outcomes while minimizing the risk of human error. Artificial Intelligence (AI) is transforming the dental industry, just like it is revolutionizing other sectors.. This review delves into the transformative potential of artificial intelligence (AI) within the realm of pediatric dentistry. As technology continues to advance, AI-driven solutions are increasingly shaping the landscape of dental care for children. From early diagnosis of dental issues to personalized treatment plans and patient education, AI offers a myriad of opportunities to enhance the delivery of pediatric dental services. This article examines the current state of AI applications in pediatric dentistry, highlighting key developments, challenges, and future prospects. By exploring the intersection of AI and pediatric dental care, this review aims to provide insights into how emerging technologies can optimize oral health outcomes and promote smiles for generations to come

Keywords: artificial intelligence; machine learning; convolutional neural network; deep learning; pediatric dentistry

Introduction:

Identifying, managing, and preventing oral health issues early is crucial for optimal oral health in children. In recent years, artificial intelligence (AI) has proven to be valuable in both dental and medical fields.[12] AI, which involves programming a machine to mimic human thinking, was first introduced by John McCarthy at a 1956 Dartmouth conference.[1,3,4]

Nowadays, AI tools are becoming increasingly significant in various dental specialties. AI programs are being developed to aid clinicians in diagnosing conditions, choosing treatments, and predicting outcomes, thereby enhancing the role of AI in healthcare.[2]

Machine learning (ML) is a branch of AI that uses algorithms to predict outcomes based on data[2]. By analyzing data, these algorithms allow machines to solve prediction problems without human help. Neural networks (NNs) are a set of algorithms that use artificial neurons to process information, similar to how

the human brain works. NNs can mimic human cognitive functions like problem-solving, learning, and decision-making.[5]

NNs consist of three layers:

1. The input layer, which receives data.
2. The hidden layer, which processes the data.
3. The output layer, where decisions are made.

The main types of NNs are artificial neural networks (ANNs), convolutional neural networks (CNNs), and recurrent neural networks. Deep learning is a type of NN that allows computers to learn and analyze data independently, with the hidden layer containing anywhere from thousands to millions of neurons.[2,6,7]

NNs train computers to respond to events rather than being told what to do. [8]Advanced AI, such as 3D CNNs, is particularly useful in dentistry for clinical tasks like cone beam computed tomography (CBCT). CBCT, which involves high radiation doses, can be replaced by CNNs in endodontics to identify anatomical features and cavities. CNNs are also crucial in oral pathology.[1]

Artificial intelligence is typically divided into three main categories: Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), and Artificial Super Intelligence (ASI). ANI, also known as weak AI, is designed to perform specific tasks and is limited to those functions. AGI, or strong AI, can solve problems similarly to a human. In dentistry, neural networks (NNs) can enhance the accuracy, speed, and efficiency of diagnoses.[3]

Classification of AI:

AI can be developed in various ways to perform different tasks, and there are multiple methods to categorize it. All forms of non-human intelligence fall under AI. AI is further divided into weak AI and strong AI. Strong AI, which has intelligence and capabilities comparable to humans, aims to create algorithms for multitasking and decision-making. Weak AI includes expert systems and machine learning (ML). Currently, deep learning, a subset of ML, is a highly researched area. Convolutional neural networks (CNNs) are a type of deep learning model mainly used for image generation and recognition. Generative adversarial networks (GANs) are another type of deep learning algorithm that uses unsupervised learning to detect patterns in input data and generate new data with similar characteristics.[9]

There is a lack of evaluation on the current applications of AI in pediatric dentistry. Therefore, this review aims to provide an update on the usefulness of AI as a diagnostic tool in pediatric dentistry.

AI Advantages:

1. Machine learning (ML) and deep learning are subfields of AI that have proven to be reliable aids in clinicians' decision-making processes.
2. They enhance monitoring, efficiency, accuracy, precision, and save time.
3. They shorten the investigation period.
4. They make it possible to improve health outcomes at lower costs.
5. They provide personalized, predictive, and preventative dentistry.

Disadvantages

1. There are limited datasets and AI models capable of detecting images that two-dimensional panoramic radiography cannot.
2. Datasets from individual institutions are not generally accessible.

AI application in pediatric dentistry

AI has a broad spectrum of applications encompassing diagnosis, decision-making, treatment planning, and predicting outcomes. AI has notably enhanced the field of diagnosis.[10]

Detection of dental caries :

AI algorithms can accurately detect dental caries by segmenting teeth, identifying cavities, and providing predictions. They analyze X-rays and intraoral images to diagnose common pediatric dental issues, such as cavities, and educate young patients.[10] Talpur et al. utilized deep-learning techniques to diagnose dental cavities through image analysis in their study.[11] Algorithms can locate edges of anatomical and pathological structures, aided by artificial neural networks (ANNs) to confirm the presence of caries.[3]

Machine learning (ML)-based models use simple questionnaires and tests to predict early childhood caries (ECC) in preschool-aged children. A new caries risk prediction model incorporating genetic and environmental factors was developed. During the COVID-19 pandemic, ML techniques like random forest were employed to select key items from parent questionnaires for forecasting active caries.[1] Karhade et al. demonstrated that ML, combined with questionnaires, can effectively diagnose and classify dental caries, particularly ECC, with high accuracy.[12]

In assessing the child's oral health and management :

AI identifies potential risk factors in pediatric oral health, transforming the collection, organization, and use of data to enhance care quality for children and adolescents. With its efficient data management capabilities, AI provides pediatric dentists with a centralized system for organizing extensive medical records, enabling quick access to important dental history information and facilitating personalized, child-centric care plans.[10] Wang, Y., et al. have developed a comprehensive AI toolkit for assessing children's oral health.[4,10]

Machine learning (ML) models and algorithms improve dental professionals' understanding and cognitive abilities by analyzing patient data, medical records, and other relevant information to make predictions and treatment recommendations.[10] AI also finds applications in orthodontics for treatment planning, locating multiple cephalometric landmarks, and predicting treatment outcomes.[9]

Fissure sealant categorization

Dental sealant adjustments are detected using convolutional neural networks (CNNs). An AI-based system achieved higher diagnostic accuracy compared to standard CNN-based classifications.

Age assessment in kids

To determine the chronological age of children and adolescents aged 4 to 15, Zaborowicz, M. et al. used three deep neural network (NN) models. Their research showed that these neural modeling algorithms could accurately assess age using specific teeth and bone indicators.[13]

Identification of tooth and anomalies

A single deep learning model is employed to diagnose mesiodens and aid in the early detection of germs in both permanent and deciduous teeth.[1,14] Convolutional neural networks (CNNs), commonly used for object recognition, are particularly effective in this context. Deep learning techniques like CNNs are increasingly utilized to evaluate and count deciduous teeth in children. The R-CNN Inception model has

demonstrated high accuracy in identifying teeth, and AI has been successful in detecting the ectopic eruption of the first permanent molar. [1]According to Bulatova et al., AI-based models are more efficient at identifying cephalometric landmarks than manual tracing.[15]

Endodontics

AI is beneficial for assessing root canal anatomy, determining working length measurements, diagnosing periapical diseases and root fractures, and predicting retreatment outcomes.[3] Zheng et al. tested three different convolutional neural networks (CNNs) for diagnosing pulpitis and deep caries using intraoral periapical images, finding that the multimodal CNN achieved high accuracy.[16]

General dentistry

AI can assist with precise shade matching [3]and has been demonstrated to be effective with CNN algorithms for automatically detecting cancer and periodontal disease.[9] Your research and that of your colleagues found that CNNs could identify dental plaque on primary teeth using intraoral photos, yielding clinically significant results.[17]

AI-supervised nanorobotic anesthesia can achieve local anesthesia painlessly.[4] However, there are significant challenges in implementing AI in dentistry, particularly regarding the exchange and storage of clinical data. While AI cannot entirely replace a dentist's diagnostic process, it can help general and pediatric dentists diagnose patients more quickly and accurately.[1]

Conclusion

Undoubtedly, AI is a valuable and powerful tool for assisting pediatric dentists. It offers high sensitivity, specificity, and accuracy as a diagnostic tool. However, further research is necessary.

Conflicts of interest There are no conflicts of interest

References

1. Vishwanathaiah S, Fageeh HN, Khanagar SB, Maganur PC. Artificial intelligence its uses and application in pediatric dentistry: A review. Biomedicines 2023;11:788. 2
2. Mahajan K, Kunte SS, Patil KV, Shah PP, Shah RV, Jajoo SS. Artificial intelligence in pediatric dentistry – A systematic review. J Dent Res Rev 2023;10:7-12.
3. Lamba J, Malhotra T, Palwankar D, Vats V, Sachdeva A. Artificial intelligence in dentistry: A literature review. Biomed J Sci and Tech Res 51:2023.
4. Magdline A, Moses J, Ranj E. Artificial Intelligence in Pediatric Dentistry: A Review. International Journal of Research Publication and Reviews. 2023;4(6):4256-4258 5.Schwendicke F, Samek W, Krois J. Artificial Intelligence in Dentistry: Chances and Challenges. J Dent Res 2020;99:769-74.
5. Thurzo A, Urbanová W, Novák B, Czako L, Siebert T, Stano P, et al. Where is the artificial intelligence applied in dentistry? systematic review and literature analysis. Healthcare (Basel) 2022;10:1269.
6. Primer A. Artificial Intelligence Versus Neural Networks. The Scientist Magazine®. Available from: https://www.the-scientist. com/magazine-issue/artificial-intelligence-versus-neural networks-65802. [Last accessed on 01 Feb 2024].
7. Ghods K, Azizi A, Jafari A, Ghods K. Application of Artificial Intelligence in Clinical Dentistry, a Comprehensive Review of Literature. J Dent (Shiraz) 2023;24:356-71.

8. Ding H, Wu J, Zhao W, Matinlinna JP, Burrow MF, Tsoi KH. Artificial intelligence in dentistry—A review. Frontiers in Dental Medicine. 2023;Feb: 1-13
9. Deepika Lakshmi R, Brindha S, Dakshitha S, Deepak N, Moses J, Ranj E. Artificial Intelligence in Pediatric Dentistry: A Review. International Journal for Multidisciplinary Research (IJFMR). 2023;5(6):1-10
10. Talpur S, Azim F, Rashid M, Syed SA, Talpur BA, Khan SJ. Uses of different machine learning algorithms for diagnosis of dental caries. J Healthc Eng 2022;2022:5032435.
11. Karhade DS, Roach J, Shrestha P, Simancas-Pallares MA, Ginnis J, Burk ZJS, et al. An automated machine learning classifier for early childhood caries. Pediatr Dent 2021;43:191-7.
12. Zaborowicz M, Zaborowicz K, Biedziak B, Garbowski T. Deep learning neural modelling as a precise method in the assessment of the chronological age of children and adolescents using tooth and bone parameters. Sensors (Basel) 2022;22:637.
13. Kılıc MC, Bayrakdar IS, Çelik Ö, Bilgir E, Orhan K, Aydın OB, et al. Artificial intelligence system for automatic deciduous tooth detection and numbering in panoramic radiographs. Dentomaxillofac Radiol 2021;50:20200172.
14. Bulatova G, Kusnoto B, Grace V, Tsay TP, Avenetti DM, Sanchez FJC. Assessment of automatic cephalometric landmark identification using artificial intelligence. Orthod Craniofac Res 2021;24 Suppl 2:37-42.
15. Zheng L, Wang H, Mei L, Chen Q, Zhang Y, Zhang H. Artificial intelligence in digital cariology: A new tool for the diagnosis of deep caries and pulpitis using convolutional neural networks. Ann Transl Med 2021;9:763.
16. You W, Hao A, Li S, Wang Y, Xia B. Deep learning-based dental plaque detection on primary teeth: A comparison with clinical assessments. BMC Oral Health 2020;20:141. Journal of Pharmacy and Bioallied Sciences ¦ Volume XX ¦ Issue XX ¦ Month 2024 View publication stats