Review Article

Artificial Intelligence in Pediatric Dentistry from Diagnosis To Decision: An Updated Review

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ABSTRACT

Artificial intelligence (AI) has emerged as a transformative tool in pediatric dentistry, offering enhanced accuracy, efficiency, and personalized care for children. AI-powered digital workflows—such as automated treatment planning, orthodontic simulations, and caries-risk prediction models—enhance clinical decision-making and reduce chairside time. In preventive dentistry, AI enables personalized recall intervals and risk-based protocols based on large datasets of pediatric oral health patterns. Additionally, virtual reality (VR) and AI-enabled gamification tools contribute to improved patient cooperation and dental education. AI-based applications assist in monitoring children's anxiety levels through facial expression analysis, enabling practitioners to tailor communication and behavior guidance strategies. Despite its advantages, the integration of AI requires considerations regarding data privacy, algorithm transparency, pediatric-specific datasets, and ethical use to ensure safe, unbiased outcomes. With appropriate regulation and clinician training, AI has the potential to significantly elevate diagnostic precision, streamline treatment processes, and improve patient compliance in pediatric dental practice. Overall, AI represents a promising adjunct to conventional pediatric dentistry, supporting clinicians in delivering more efficient, child-centered, and evidence-based care. This article explores the applications of artificial intelligence in early diagnosis, treatment planning, behavior management for children using virtual reality, augmented reality and some AI based apps, softwares that are in use.

Key words: Artificial intelligence (AI), virtual reality, diagnosis, treatment planning, AI Apps

Artificial intelligence (AI), or human intellect displayed by computers, was first put forth by Professor John McCarthy at Dartmouth College in the summer of 1956. Since then, it has been a term used by computer scientists, science fiction enthusiasts, and medical researchers of various generations [1]. Creating computer systems that are capable of carrying out tasks that normally call for human intelligence is known as artificial intelligence (AI). In order to build intelligent machines that can mimic human thought and decision-making processes, this multidisciplinary field integrates computer science, mathematics, psychology, and other fields [2].

HISTORY AND EVOLUTION OF AI

The "Turing Test" was the first AI-related query in the 1950s; many academics believe that the 1956 Summer Dartmouth Conference on AI is where artificial intelligence was first conceived [3]. In the 1970s, AI with observable medicinal uses started to gain traction. The first artificial medical consultant in history, INTERNIST-1, was developed in 1971. Based on the symptoms of the patients, the system used a search algorithm to determine clinical diagnoses. Using a set of input criteria, the MYCIN system enabled doctors prescribe the right medications to patients with infectious disease. A tool called DXplain was created to assist medical professionals in making a diagnosis [3].

Oral disease diagnostics was the first significant use of artificial intelligence (AI) in dentistry. DXplain, a clinical decision-support system created at Massachusetts General Hospital in the 1980s and later modified for use in dentistry diagnosis. Early AI applications were specifically utilized in dentistry in the late 1980s and early 1990s for radiograph interpretation, caries identification, and support for differential diagnosis [4].

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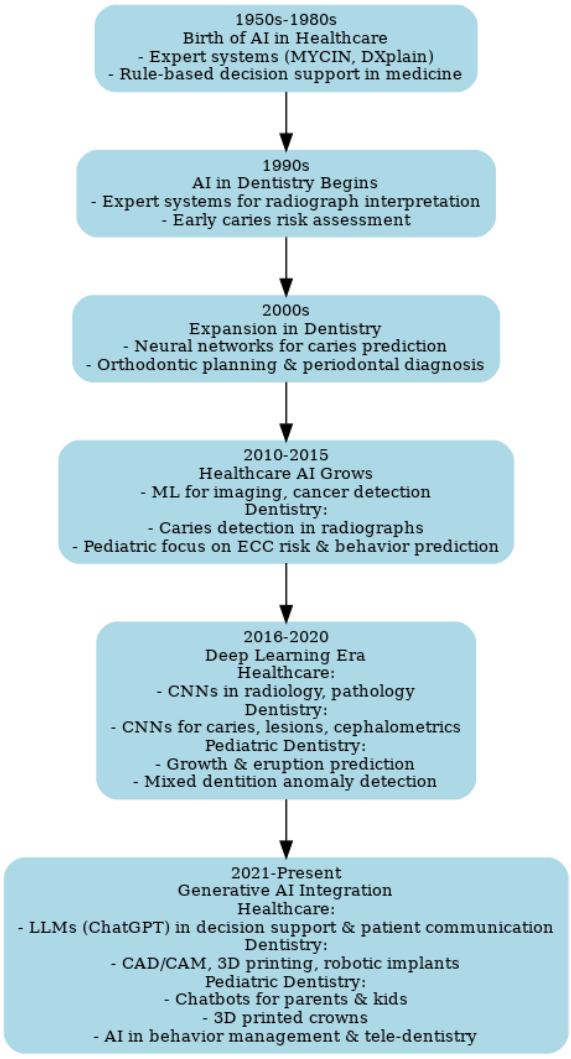
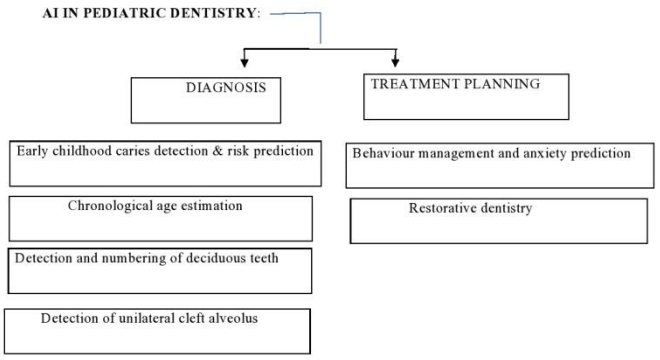


Flowchart 1 showing the evolution of AI into healthcare

TYPES OF AI USED IN DENTISTRY

Narrow AI and wide AI are the two main categories of AI. Often referred to as weak AI, narrow AI is made to be exceptionally good at certain activities, like autonomous driving, picture recognition, and language translation. It works within clearly specified parameters and concentrates on performance optimization within them. On the other hand, artificial general intelligence, often known as strong AI, describes AI systems that are comparable to humans in their ability to comprehend, learn, and apply information across a range of tasks. Even though general artificial intelligence is a theoretical idea, research and development in this field are still ongoing [2].

Over the past 20 years, a variety of AI applications in dentistry have been introduced. Machine learning, one of the most used forms of AI, was the first to be used in dentistry. The goal of machine learning (ML) was to use algorithms to create a computer or system that could learn and function without needing to be explicitly programmed to plan and dictate every move. Artificial neural networks, a different kind of AI, were launched concurrently with the quick development of AI in dentistry. The goal of this program was to create information processing that was modeled like the neural network seen in the human brain. In other words, rather than prescribing what must be done, the neural network assisted in teaching computers to react correctly to situations. Together with other processing components, each neuron in this network represents a processing element that solves various problems Deep learning (DL) is arguably the most recent advancement of AI systems in dentistry. Neural networks with multiple layers are used in this system. A portion of the input data is analyzed by each of these layers. Thus, using unlabeled and unstructured data, this process forecasts results [5].



Flowchart 2 showing the uses of AI in diagnosis and treatment planning

AI IN DETECTING EARLY CHILDHOOD CARIES

The most prevalent child disease in the world, early childhood caries (ECC) is a health inequity that affects children from underprivileged backgrounds. If identified early, ECC is both preventive and reversible. However, access to dental care is a challenge for many kids from low-income households. The overwhelming incidence of ECC may be addressed by an at-home caries screening tool, which might also provide access to dental care regardless of a patient's financial situation. An AI-powered smartphone app that is easy for patients to use and can identify caries could help with the early diagnosis and treatment of ECC. Recently a study conducted on workflow of AICaries app which provides

a) AI-driven caries detection with photographs of children's teeth captured by parents' cellphones,

b) An interactive caries risk assessment,

c) Tailored teaching on mitigating children's ECC risk. The perceived advantages of utilizing the AICaries app encompass quick at-home caries screening, instructive insights on caries risk and education, and the engagement of family members [6].

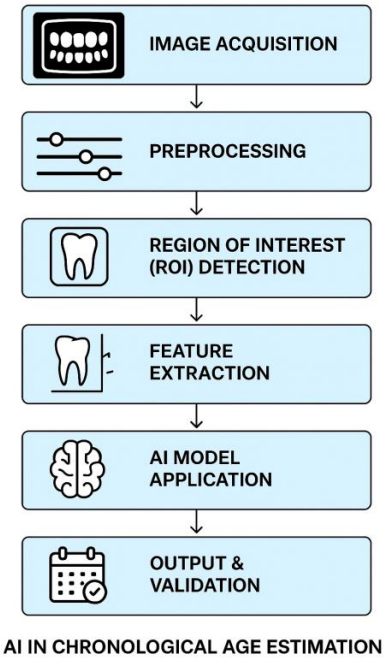
RISK PREDICTION

Tools for evaluating the risk of dental caries are essential for classifying patients, educating them, and improving care. These tools combine different risk and protective factors to give patients a subjective risk rating (low, moderate, or high).

Furthermore, the present work shows that an extremely reduced-input model, requiring only two predictors, was sufficient to yield the strongest classification performance for early childhood caries. Among the variables tested, a caregiver-reported question about the child's oral health provided greater discriminatory value than several conventional caries-risk indicators. This suggests that a simple model built with only the child's age and parental perception of oral health can approximate ECC likelihood with acceptable accuracy, even in the absence of chairside clinical assessment [7, 8].

AI IN CHRONOLOGICAL AGE ESTIMATION

Age estimation can be accomplished more quickly, effectively, and accurately by creating AI-powered tools that evaluate entire panoramic radiograph pictures without requiring previous manual review [9].



FLOWCHART 3: showing the workflow of AI in chronological age estimation [10]

Out of all the AI models used for age estimation, the study by Mualla et al. had the greatest accuracy of 98.8% and precision of 99.05% [11].

AI IN DETECTION AND NUMBERING OF DECIDUOUS TEETH

For tooth detection, Oktay suggested a CNN model that was altered using the AlexNet architecture [12]. Jader et al. suggested employing transfer learning techniques in conjunction with a mask-region-based CNN approach to segment the teeth. This method's superiority was demonstrated by its 98% accuracy, 88% F1 score, 94% precision, 84% recall rate, and 99% specificity [13]. For automated tooth segmentation, Lee et al. employed a comprehensive deep-learning mask-R-CNN technique that was executed through a fine-tuning procedure. It was shown that automated teeth segmentation on panoramic radiographs performed at a high level [14]. Using Faster R-CNN Inception v2 (COCO) models, an artificial intelligence (AI) program (CranioCatch, Eskisehir-Turkey) was created to automatically identify and count deciduous teeth on pediatric panoramic radiographs. The AI algorithm was able to identify and count the children's deciduous teeth as shown on panoramic radiography. Both the accuracy and sensitivity rates were high [12].

AI IN DETECTION OF UNILATERAL CLEFT ALVEOLUS

AI applications have improved diagnosis, prognosis, treatment, and education for cleft lip and palate. Prevention and care are enhanced by tools like genetic variability modeling, surgical planning, and diagnostic algorithms [15].

Table 1: AI models and their uses in detection of unilateral cleft alveolus

AUTHOR	MODEL	USE	INFERENCE
Almoammar et al [16]	Neural networks [NN]	Early diagnosis and monitoring	Used trained CNN models to identify landmarks and classify defects with an accuracy of upto 89%
Hugh et al [17]	AI based software	Surgical planning	Suggested comparative research on cephalometric computations to address maxillary growth disparity

AI IN BEHAVIOUR MANAGEMENT

According to the "attentional capacity theory," in order to get a child's attention, "distracting stimuli" must be more potent than "pain stimuli" [18]. By demonstrating or simulating animated images about common dental instruments and simple dental procedures with visuals and sound/audio effects, dental games or apps on smartphones can be used as a modulation of TSD technique. By providing individualized and sympathetic support, artificial intelligence (AI) may be beneficial in reducing children's needle phobia and fear of dental extractions [2].

TABLE 2: Stages in Behaviour Management Using AI [19]

Stage	Description
Initial Assessment	An AI system uses biometric data (e.g., heart rate, voice analysis) and facial expressions to assess the child's initial anxiety level before the procedure begins.
Personalized Intervention	Based on the real-time AI assessment, the system recommends a tailored digital modality — either Virtual Reality (VR) or Augmented Reality (AR) — to manage the child's behavior.
Immersive Experience	The child is engaged in a personalized digital experience. VR can create a fully immersive, calming world, while AR can overlay a game or fun characters onto the real-world view.
Reduced Anxiety & Cooperation	The distraction from the digital experience helps to reduce the child's fear and anxiety, leading to a calmer state and improved cooperation with the dentist throughout the procedure.

AI IN PEDIATRIC RESTORATIVE DENTISTRY:

Computer-aided design and computer-aided manufacturing (CAD/CAM) technology is at the heart of this shift and is now crucial to children's restorative operations. The notable decrease in treatment duration is one of the primary benefits; shorter treatment sessions are better accepted by young children, who sometimes suffer with lengthy dental procedures.

Table 3: Advantages And Disadvantages Of Using AI In Pediatric Restorative Dentistry [20]

ADVANTAGES	DISADVANTAGES
Chair side single visit restorations -reduce anxiety and need for multiple visits	High cost – equipment and materials are expensive
Digital impressions -avoids discomfort from traditional impression materials	Technique sensitive -requires training and expertise
High accuracy and fit -improves restoration quality	Limited use in very young /uncooperative children difficult to obtain proper scans
Durable material and less invasive procedures	Equipment maintainence – needs regular updates and servicing

LIMITATIONS AND DRAWBACKS OF AI:

Although artificial intelligence has many benefits, there may also be drawbacks or difficulties. These include concerns about safety and diagnostic precision, high implementation costs, shifts in the nature of labor, and unemployment.The greatest limitation is that pertinent data is inaccessible. For ML and DL models to accurately identify or forecast a wide range of occupations, massive datasets are needed. The industries with the easiest access to big datasets have seen the biggest breakthroughs in machine learning's capacity to produce increasingly sophisticated and precise algorithms. Access to information is a complicated problem for the healthcare industry.Due to ambiguity in the domains of accountability and duty, the development of artificial intelligence in healthcare applications presents difficult ethical issues [21].

AI APPS AND SOFTWARES THAT ARE IN USE :

DIAGNOCAT AI:

It is an Al powered software platform for dental Image analysis it handles 2D X-rays like intraoral periapical radiographs, OPG and 3D scans [CBCT] ,found in 2017-2018, this software offers cloud based services so that dentist uploads the image choses the report type, and the Al generates an analysis and visual report

Applications:

- Early Caries Detection
- Mixed Dentition Analysis
- Monitoring Of Tooth Development
- Treatment Planning
- Communication With Patients
- Orthodontic screening in children/ adolescent [22]

Dentist Al app:-

This is also Al powered software app, here the clinical photographs of the patient can be uploaded and the overall dental health score can be analyzed. This Al app detects the calculus plaque, caries and restorations if any and gives brief report about the oral health of the child , this can be used as pre-visit app by the parents of children to analyse the oral health of children. Food analyzer section of this app can be utilized to assess the micronutrients present in the food and also sugar impact, acid impact, calorie impact of the food and the high sugar level can be indicated by red mark. Based on the above findings. the app also suggests the preventive measures that are needed to be undertaken by the parents inorder to prevent the occurence of oral diseases like dental caries .The tracker interface of the app can be used to track the daily improvement in the oral hygiene.

Applications of this app:

- Caries Detection and Diagnosis
- Treatment Planning Support
- Caries Risk Assessment
- Monitoring Oral Hygiene
- Patient Education and Communication
- Progress Tracking [23]

AI CARIES APP:

Using images of children's teeth, this experimental smartphone app employs artificial intelligence to detect dental caries. To find dental cavities, the intraoral photos are uploaded. It offers a convenient at-home screening as well as education and information on caries risk. The AICaries app exemplifies how AI-powered mobile health solutions can enable caregivers to identify early caries, encourage oral health education, and lessen disparities in children's access to dental care [24]

OTHER APPLICATIONS THAT ARE AVAILABLE:

SCAN O APP [25]

OVERJET AI [26]

TEETH SNAP SMART AI DENTIST [27]

DEN PERFECT POCKET AI DENTIST [28]

TEETH AI – DENTAL SCANNER APP [29]

CONCLUSION

Artificial Intelligence is emerging as a powerful tool in pediatric dentistry, enhancing diagnosis, treatment planning, patient monitoring, and education. From caries detection on radiographs to growth prediction and orthodontic planning, AI offers greater accuracy, efficiency, and child-friendly approaches. It also supports preventive care by analyzing risk factors and enabling personalized treatment strategies. However, challenges such as high cost, data privacy, technical limitations, and the need for clinical validation still exist. Overall, AI holds great promise to transform pediatric dentistry into a more precise, efficient, and patient-centered discipline. Both individuals and communities can benefit greatly from AI models, which are useful for detecting and classifying children into risk groups, recognizing and numbering teeth, diagnosing early ectopic eruption, assessing age, and more. Children can become more conscious of their own dental health by using them to help create and evaluate oral health. AI can be utilized as a supplemental tool in a controlled manner, maintaining the human element and reaffirming that dentists and pediatric dentists are ultimately in charge of making judgments and regulating treatment procedures. But the time when AI and dentists work together to improve patient care is not far off.

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