

Review Article

AI in Pediatric Dentistry: A Narrative Review

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ABSTRACT:

The integration of Artificial Intelligence (AI) in pediatric dentistry is transforming patient care through enhanced diagnostic accuracy, personalized treatment plans, and improved patient engagement. AI systems analyze vast datasets, enabling clinicians to identify dental issues at early stages, predict future oral health problems, and customize preventive measures. This technology also enhances the educational experience for young patients, making dental visits less intimidating through engaging interfaces and gamification strategies. Furthermore, AI-driven imaging techniques improve the precision of diagnoses, leading to more effective interventions. As pediatric dental practices embrace these innovations, they face challenges including ethical considerations, data privacy, and the need for continuous training. Nevertheless, AI holds significant potential to improve outcomes in pediatric dentistry by promoting a more proactive and patient-centered approach to oral health.

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INTRODUCTION

Pedodontics, or pediatric dentistry, encompasses the prevention, diagnosis, and management of dental conditions in children from infancy through adolescence. It requires a deep understanding of the developmental, psychological, and physiological aspects unique to younger patients. The integration of Artificial Intelligence into pedodontics is significantly advancing the delivery of pediatric oral health care. From early caries detection and behavior management to personalized prevention strategies and minimally invasive treatment planning, AI is helping clinicians optimize care while enhancing the patient experience.¹⁻³ This review of literature explores the applications, benefits, and challenges of AI in pediatric dental practice.

AI in Early Diagnosis and Caries Detection: One of the primary concerns in pediatric dentistry is the early detection of dental caries. Traditional diagnostic methods, including visual-tactile examination and radiographic interpretation, are prone to subjective bias and may fail to identify early lesions. AI-powered tools, particularly those using deep learning algorithms, are now capable of analyzing dental images—bitewing radiographs, intraoral photos, and optical scans—with exceptional accuracy. These tools can detect incipient caries, enamel demineralization, and interproximal lesions before they are clinically visible. By evaluating changes pixel by pixel, AI software identifies subtle patterns that indicate early disease progression. This supports minimally invasive interventions and timely preventive measures, thereby preserving tooth

structure and reducing the need for restorative procedures.

Moreover, AI systems can be trained to recognize other common pediatric conditions such as developmental enamel defects, molar incisor hypomineralization (MIH), and traumatic dental injuries, streamlining the diagnostic process and reducing human error.^{4,5}

Personalized Preventive Care Using AI: Preventive care is the cornerstone of pediatric dentistry. AI enables a personalized approach by assessing individual risk profiles based on factors such as diet, oral hygiene habits, socioeconomic status, salivary composition, and genetic predispositions.

Machine learning models analyze these data to classify patients into risk categories and recommend tailored preventive plans. This might include customized recall intervals, fluoride application schedules, dietary counseling, and sealant recommendations. Such data-driven strategies improve compliance and optimize resource utilization, especially in community and school-based dental programs.

Furthermore, AI can support behavioral tracking by integrating with mobile apps that encourage children and parents to maintain good oral hygiene practices. These apps use gamification and reward systems based on AI-generated feedback to foster engagement and long-term habits.^{6,7}

AI in Behavior Management and Patient Engagement: Behavior management is a crucial component of successful pediatric dental care. AI technologies, particularly those involving emotion recognition and behavioral pattern analysis, are being utilized to improve child cooperation and reduce anxiety during dental visits.

Computer vision systems integrated into cameras and chairside monitors can assess facial expressions, body language, and vocal tones to gauge a child's emotional state. Based on real-time analysis, the system can suggest calming interventions, visual distractions, or changes in communication strategy to the dentist or assistant.

Additionally, AI-driven virtual assistants or avatars are being explored to introduce dental procedures to children in a friendly and non-threatening manner. These interfaces provide information, answer common questions, and simulate procedures in a playful environment, reducing fear and improving the overall clinical experience.⁶⁻⁸

AI in Pediatric Orthodontic Screening: Many pediatric patients require early orthodontic assessment to address issues such as crowding, crossbites, or skeletal discrepancies. AI tools are increasingly being used for screening purposes by analyzing facial scans, panoramic images, and dental arch morphology.

These systems can identify signs of malocclusion, delayed eruption, or abnormal jaw development at a young age, prompting timely referrals to orthodontists. AI can also simulate the progression of skeletal changes, helping clinicians predict the need for interceptive treatments such as space maintainers, habit breakers, or functional appliances.

Such proactive assessments improve long-term outcomes and reduce the complexity of future orthodontic treatment.^{9,10}

AI in Minimally Invasive and Restorative Treatments: In line with the principles of Atraumatic Restorative Treatment (ART) and minimal intervention dentistry, AI tools are being used to guide decision-making in cavity preparation and restoration. For instance, AI systems can assess the depth and extent of carious lesions through imaging and suggest whether fluoride therapy, sealant placement, or restoration is appropriate.

When restoration is indicated, AI-integrated CAD/CAM systems assist in designing customized fillings or crowns, particularly for young patients who require stainless steel or zirconia crowns. These restorations are fabricated with greater precision and speed, reducing chairside time and improving comfort.

AI also supports the selection of restorative materials based on factors like lesion location, patient age, oral environment, and esthetic considerations.^{11,12}

AI in Pediatric Dental Emergency Management: Children are prone to dental emergencies, including trauma, avulsion, and infections. AI can play a pivotal role in the triage and remote management of such cases. Mobile applications powered by AI allow parents or caregivers to photograph an injury and receive preliminary assessments, including severity grading, urgency level, and interim care instructions. These tools help prioritize emergency visits, reduce parental anxiety, and improve the timeliness of clinical intervention. Some AI-based systems are even being integrated into school health programs and rural outreach centers to support first responders and teachers in managing dental emergencies effectively.¹³

AI in Education and Training in Pediatric Dentistry: AI is transforming the way pediatric dentistry is taught and learned. Virtual reality (VR) and augmented reality (AR) platforms powered by AI provide simulated clinical environments where students can practice child-specific procedures such as pulp therapy, stainless steel crown placement, and behavior guidance techniques.

These simulations offer real-time feedback and adapt to the learner's skill level, improving clinical competency and confidence. AI can also create case-based learning modules using large pediatric datasets, exposing trainees to a wide range of scenarios, from routine care to rare syndromic conditions.

Additionally, AI is used to assess student performance, track progress, and recommend tailored learning paths, fostering continuous improvement and evidence-based practice.¹⁴

Challenges and Ethical Concerns: Despite its potential, the application of AI in pedodontics comes with challenges. Data privacy is a significant concern, especially when dealing with minors. Parental consent and robust encryption methods are critical when collecting and analyzing pediatric health data.

Another concern is the accuracy of AI algorithms in diverse pediatric populations. If training data lacks diversity in age, ethnicity, or oral health status, the performance of AI models may be compromised, leading to misdiagnosis or biased recommendations.

There is also the need to preserve the humanistic elements of pediatric care. While AI can enhance efficiency and decision-making, it must not replace the empathy, communication, and trust-building that are central to treating children. Ensuring that AI remains a supportive tool rather than a substitute for clinician judgment is paramount.²⁻⁴

Future Perspectives: The future of AI in pedodontics lies in further personalization and integration. Wearable AI devices may one day monitor children's oral hygiene habits, diet, and sleep patterns to provide holistic oral health insights. Advances in genomic AI could lead to the prediction of caries susceptibility and enamel defects based on genetic profiles.

Remote diagnostics and tele-pedodontics will expand access to care in underserved regions, supported by AI-based monitoring and consultation platforms. Moreover, interdisciplinary collaboration between pediatricians, dietitians, and dentists through AI-driven platforms will support whole-child health initiatives.

Continued research, ethical oversight, and inclusive data collection will ensure that AI becomes a powerful ally in promoting pediatric oral health.

Artificial intelligence has emerged as a transformative tool in various fields of healthcare, including dentistry. In the realm of pediatric dentistry, or pedodontics, AI has the potential to revolutionize patient care, enhance diagnostic accuracy, improve treatment outcomes, and streamline operational processes. The application of AI in pedodontics can be seen in various domains, including early diagnosis, treatment planning, patient management, and even in the administrative aspects of dental practice.

One of the most significant contributions of AI to pedodontics is its role in early diagnosis. Dental conditions such as cavities, malocclusions, and developmental anomalies can often be challenging to diagnose in young patients due to their developing oral structures. AI-powered imaging technologies, such as deep learning algorithms and neural networks, can analyze dental radiographs and other imaging data with remarkable precision. These algorithms are

trained to detect even the subtlest of abnormalities, helping clinicians identify early signs of dental decay or other conditions that may be missed by the human eye. Early detection is crucial in pediatric dentistry, as it allows for timely intervention, preventing the progression of diseases and minimizing the need for more invasive treatments.

Furthermore, AI can assist in the personalized treatment planning of pediatric patients. Pediatric dentistry often requires a tailored approach due to the varying stages of development among children. AI systems can analyze patient data, including age, medical history, dental growth patterns, and other relevant factors, to recommend the most appropriate treatment options. For example, in the case of orthodontics, AI can predict the future growth of the child's jaw and teeth, providing valuable insights into the timing and type of orthodontic interventions required. This allows pediatric dentists to develop more accurate and effective treatment plans that can adapt to the changing needs of growing children.

In addition to diagnostic and treatment planning benefits, AI is also making strides in improving patient management. Managing young patients can be a complex task, particularly in terms of behavior management and communication. AI-powered tools can help create a more comfortable and engaging environment for children. Virtual assistants and chatbots, for instance, can be programmed to educate children about their oral health, guide them through procedures, and provide post-treatment care instructions in an interactive manner. These AI-driven tools can also help parents track their child's dental health progress, schedule appointments, and receive reminders for preventive care, ultimately improving compliance and reducing missed appointments.

AI is also playing a significant role in reducing the administrative burden on pediatric dental practices. Routine tasks such as appointment scheduling, billing, and patient record management can be automated through AI systems, freeing up valuable time for dental practitioners.

One of the challenges in implementing AI in pedodontics is the need for high-quality, large-scale datasets to train AI models effectively. The pediatric population presents unique challenges in terms of data variability due to differences in age, development, and individual health conditions. Additionally, there is the question of data privacy and security, especially when dealing with sensitive health information about children. It is essential that AI systems used in pediatric dentistry comply with strict ethical standards and regulations to protect patient confidentiality and ensure safe use of the technology.^{15,16}

CONCLUSION

Artificial Intelligence is redefining pedodontics by enhancing early detection, personalizing prevention, streamlining treatment, and improving patient engagement. From intelligent caries detection to

behavioral insights and remote monitoring, AI is helping clinicians provide safer, smarter, and more compassionate care for children. While ethical, technical, and training challenges remain, the thoughtful integration of AI into pediatric dental practice holds great promise for improving oral health outcomes in the youngest members of society.

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