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Review Article

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AI-Enabled IT Systems for Improved Dental Practice Management

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Abstract

Artificial intelligence (AI) is rapidly transforming various sectors, and dental practice management is no exception. This paper explores the potential of AI-enabled IT systems to revolutionize dental operations, enhancing efficiency, patient care, and overall practice outcomes. By automating routine tasks such as appointment scheduling, patient communication, and billing, AI frees up staff time for more complex and patient-focused activities. Furthermore, AI algorithms can analyze patient data, including radiographs and clinical records, to provide valuable insights for diagnosis, treatment planning, and personalized care. This paper examines key applications of AI in dental practice management, including patient relationship management (PRM), clinical decision support, operational optimization, and fraud detection. It also discusses the benefits of AI adoption, such as improved efficiency, reduced costs, enhanced patient satisfaction, and data-driven decision-making. Finally, the paper addresses the challenges and considerations associated with implementing AI systems, including data privacy, integration with existing systems, and ethical implications. The findings suggest that AI-enabled IT systems offer significant potential to improve dental practice management and contribute to better patient outcomes.

Keywords: Artificial intelligence; dental practice management; IT systems; automation; patient care; clinical decision support; patient relationship management; operational efficiency; data analytics; healthcare technology; digital dentistry

Introduction

The healthcare landscape is undergoing a significant transformation driven by advancements in artificial intelligence (AI). From drug discovery and diagnostics to personalized medicine and patient monitoring, AI is reshaping how healthcare is delivered and managed. Within this broader context, the dental profession stands to benefit significantly from the integration of AI-enabled IT systems. Traditionally reliant on manual processes and paper-based records, dental practices face increasing pressure to improve efficiency [1, 2], enhance patient care, and remain competitive in a

rapidly evolving digital world. AI offers a powerful solution to address these challenges, promising to revolutionize dental practice management in profound ways.

For decades, dental practices have relied on practice management software to handle basic administrative tasks like scheduling, billing, and record-keeping. However, these systems often lack the advanced analytical capabilities and automation features that AI provides. AI-powered systems can go beyond simple task management, offering intelligent insights derived from patient data,



automating complex workflows [3-5], and enabling personalized patient experiences. This shift represents a paradigm change, moving from reactive management to proactive and predictive practice optimization.

The potential benefits of AI in dental practice management are multifaceted. Firstly, AI can significantly enhance operational efficiency. By automating routine tasks such as appointment scheduling, patient communication (e.g., appointment reminders, post-operative instructions), and insurance claims processing, AI frees up valuable staff time, allowing them to focus on more complex and patient-centric activities. This automation not only reduces administrative burden but also minimizes human error, leading to improved accuracy and cost savings. Secondly, AI can significantly improve patient care. AI algorithms can analyze various data sources, including radiographs, intraoral scans, and patient medical history, to assist dentists in diagnosis, treatment planning, and risk assessment. For example, AI can detect subtle signs of caries, periodontal disease, or even oral cancer in radiographic images, potentially leading to earlier diagnosis and improved treatment outcomes. Moreover, AI can personalize patient communications and treatment plans based on individual needs and preferences, enhancing patient satisfaction and adherence.

The integration of AI in dental practice management is not merely about automating existing processes; it is about creating new possibilities for improved patient care and practice efficiency. One key area where AI is making a significant impact is clinical decision support. AI algorithms, trained on vast datasets of clinical data, can provide dentists with evidence-based recommendations for diagnosis, treatment planning [6, 7], and prognosis. This can be particularly valuable in complex cases or for less experienced practitioners, providing an additional layer of support and ensuring consistent, high-quality care. Furthermore, AI can facilitate the development of personalized treatment plans tailored to each patient's specific needs and circumstances. By analyzing individual patient data, including genetic predispositions, lifestyle factors, and treatment history, AI can help dentists predict treatment outcomes and optimize treatment strategies.

Another promising application of AI is in patient relationship management (PRM). AI-powered PRM systems can analyze patient data to identify at-risk patients, personalize communication strategies, and improve patient engagement. For instance, AI can identify patients who are overdue for check-ups or who have a history of missed appointments and automatically send targeted reminders. AI can also analyze patient feedback and sentiment to identify areas for improvement in patient experience. This proactive approach to patient management can lead to increased patient retention, improved patient satisfaction, and enhanced practice reputation.

Beyond these core areas, AI is also being explored for applications such as fraud detection in insurance claims, inventory management, and predictive analytics for forecasting patient volume and resource needs. By analyzing claims data, AI can identify suspicious patterns and potential fraud, helping to reduce costs and

improve the integrity of the dental insurance system. In inventory management, AI can optimize stock levels and automate ordering processes, reducing waste and ensuring that essential supplies are always available. Predictive analytics can help practices anticipate future demand for services and allocate resources effectively, optimizing staffing levels and minimizing downtime.

However, the adoption of AI in dental practice management also presents certain challenges. These include concerns about data privacy and security, the need for seamless integration with existing practice management systems, the cost of implementation, and ethical considerations related to the use of AI in healthcare. Addressing [8-10] these challenges is crucial for the successful and responsible implementation of AI in dental practices. The following sections will delve deeper into the specific applications of AI in dental practice management, explore the benefits and challenges associated with its adoption, and discuss the future direction of this transformative technology.

Methodology

The methodology employed in this exploration of AI-enabled IT systems for improved dental practice management involves a comprehensive and multifaceted approach, drawing upon various research methods and data sources to provide a holistic understanding of the topic. The key components of this methodology are outlined below:

Literature Review: A thorough review of existing academic literature, industry publications, and reputable online resources was conducted to establish a strong foundation of knowledge on the subject. This included:

- **Academic Databases:** Utilizing databases such as PubMed, IEEE Xplore, ScienceDirect, and Google Scholar to identify relevant research articles, conference proceedings, and book chapters.
- **Industry Publications:** Examining publications from dental associations, technology providers, and healthcare consulting firms to gather insights into current trends and best practices.
- **Online Resources:** Reviewing reputable websites, blogs, and reports from organizations such as the American Dental Association (ADA), the National Institute of Dental and Craniofacial Research (NIDCR), and leading technology companies in the dental industry.

Data Collection and Analysis: Gathering and analyzing data from various sources to support the research findings and provide evidence-based insights. This involved:

- **Case Studies:** Examining real-world examples of dental practices that have implemented AI-enabled IT systems to understand the practical applications and outcomes.
- **Surveys and Interviews:** Analyzing [11, 12] data from surveys and interviews with dental professionals, technology providers, and patients to gather firsthand perspectives on the

benefits, challenges, and user experiences associated with AI in dental practice management.

- **Technology Demonstrations and Evaluations:** Reviewing demonstrations and evaluations of AI-powered dental software and hardware to assess their capabilities and potential impact on practice operations.

Conceptual Framework: Developing a conceptual framework to organize and synthesize the information gathered from the literature review and data analysis. This framework focuses on the key applications of AI in dental practice management, including:

- **Patient Communication and Scheduling:** Examining how AI can automate appointment scheduling, patient reminders, and communication.

- **Clinical Decision Support:** Analyzing the role of AI in assisting with diagnosis, treatment planning, and risk assessment.

- **Operational Efficiency:** Investigating how AI can optimize workflows, inventory management, and resource allocation.

- **Billing and Insurance:** Exploring the use of AI in automating claims processing and fraud detection.

- **Patient Relationship Management (PRM):** Assessing how AI can personalize patient interactions and improve patient engagement.

Evaluation and Discussion: Evaluating the potential benefits and challenges associated with implementing AI-enabled IT systems in dental practices. This includes:

- **Benefits Assessment:** Analyzing the potential for AI to improve efficiency, patient care, reduce costs, and enhance data-driven decision-making.

- **Challenges Identification:** Identifying potential barriers to adoption, such as data privacy concerns, integration issues, cost of implementation, and ethical considerations.

- **Future Directions:** Discussing the future trends and potential advancements in AI technology that could further transform dental practice management.

Synthesis and Conclusion: Synthesizing the findings from the various research methods and data sources to provide a comprehensive overview of the current state and future potential of AI in dental practice management. This involves drawing conclusions based on the evidence gathered and offering recommendations for dental professionals, technology providers, and policymakers.

Advantages and Disadvantages of AI in Dental Practice Management

The integration of artificial intelligence (AI) [13-15] into dental practice management offers a compelling array of potential benefits, but it's crucial to acknowledge the associated challenges and

limitations. A balanced perspective is essential for successful implementation and responsible use of AI in this context.

Advantages of AI in Dental Practice Management:

- **Improved Efficiency and Productivity:** AI automates routine tasks such as appointment scheduling, patient reminders, billing, and insurance claims processing. This frees up staff time to focus on patient care and other high-value activities, leading to increased productivity and reduced administrative burden.

- **Enhanced Patient Care and Diagnostics:** AI algorithms can analyze various data sources, including radiographs, intraoral scans, and patient medical history, to assist dentists in diagnosis, treatment planning, and risk assessment. AI can detect subtle anomalies that may be missed by the human eye, potentially leading to earlier diagnosis and improved treatment outcomes.

- **Personalized Patient Experiences:** AI can personalize patient communications and treatment plans based on individual needs and preferences. This can lead to increased patient satisfaction, improved treatment adherence, and stronger patient-dentist relationships.

- **Data-Driven Decision Making:** AI provides valuable insights from patient data, enabling dentists to make informed decisions about treatment strategies, resource allocation, and practice management. Predictive analytics can forecast patient volume, identify at-risk patients, and optimize inventory management.

- **Reduced Errors and Costs:** Automation and data analysis can minimize human error in tasks such as billing, coding, and record-keeping. This can lead to cost savings by reducing the need for rework and minimizing financial losses due to errors.

- **Improved Patient Communication and Engagement:** AI-powered chatbots and virtual assistants can handle routine patient inquiries, provide pre- and post-operative instructions, and send appointment reminders, improving patient communication and engagement.

- **Enhanced Fraud Detection:** AI can analyze claims data to identify suspicious patterns and potential fraud, helping to protect dental practices and insurance providers from financial losses.

- **24/7 Availability:** AI-powered systems, such as chatbots, can provide patients with access to information and support around the clock, improving patient convenience and accessibility.

Disadvantages of AI in Dental Practice Management:

- **Data Privacy and Security Concerns:** The use of AI in dental practice management involves collecting and storing large amounts of sensitive patient data. Ensuring the privacy and security of this data is paramount, and robust security measures are essential to prevent data breaches and unauthorized access.

- **Integration Challenges:** Integrating AI systems with existing practice management software and hardware can be complex and challenging. Seamless integration is crucial for efficient workflow and data exchange.
- **Cost of Implementation:** Implementing AI systems can require significant upfront investment in software, hardware, and training. This can be a barrier for smaller practices with limited budgets.
- **Lack of Human Interaction:** While AI can automate many tasks, it cannot completely replace human interaction and empathy. Maintaining a strong patient-dentist relationship is crucial for patient satisfaction and trust.
- **Ethical Considerations:** The use of AI in healthcare raises ethical concerns related to bias in algorithms, data ownership, and the potential for over-reliance on technology. It is important to ensure that AI is used responsibly and ethically.
- **Dependence on Technology:** Over-reliance on AI systems can create vulnerabilities if the technology malfunctions or becomes unavailable. Having backup plans and contingency measures is essential.
- **Need for Training and Expertise:** Dental staff need to be trained on how to use and interpret the output of AI systems effectively. This requires ongoing training [16] and support.
- **Potential for Job Displacement:** While AI is more likely to augment human capabilities rather than completely replace jobs, there may be some job displacement in certain administrative roles.

Challenges of AI in Dental Practice Management

While AI offers significant potential to revolutionize dental practice management, several challenges must be addressed to ensure successful and responsible implementation. These challenges span technical, ethical, and practical considerations:

Data Privacy and Security:

- AI systems rely on vast amounts of patient data, including sensitive medical history, treatment records, and financial information.
- Protecting this data from breaches and unauthorized access is paramount. Robust security measures, compliance with regulations like HIPAA, and transparent data governance policies are crucial.
- Patients need to trust that their data is handled responsibly, and practices must be transparent about how data is collected, used, and protected.

Integration with Existing Systems:

- Many dental practices use legacy practice management software that may not be easily compatible with AI systems.
- Seamless integration is essential for efficient workflows and data exchange. This may require significant investment in up-

grading existing systems or developing new integration solutions.

- Data standardization and interoperability [17, 18] between different systems are crucial for effective data sharing and analysis.

Cost of Implementation:

- AI systems can require significant upfront investment in software, hardware, and training.
- This can be a barrier for smaller practices with limited budgets.
- Cloud-based AI solutions and subscription models may offer more affordable options for some practices.

Lack of Human Interaction and Empathy:

- While AI can automate many tasks, it cannot completely replace human interaction and empathy, which are crucial for building trust and rapport with patients.
- Maintaining a human-centered approach is essential, ensuring that AI augments rather than replaces human interaction.
- Dental professionals need to balance the use of AI with personalized communication and care.

Ethical Considerations:

- **Bias in algorithms:** AI algorithms are trained on data, and if that data reflects existing biases, the AI system may perpetuate those biases in its decisions. Ensuring fairness and equity in AI algorithms is crucial.
- **Data ownership and usage:** Clear policies are needed regarding data ownership, usage, and sharing. Patients need to understand how their data is being used and have control over their data.
- **Over-reliance on technology:** It's important to avoid over-reliance on AI [19, 20] and maintain human oversight of AI systems. Dental professionals need to be able to critically evaluate the output of AI and make informed decisions.

Need for Training and Expertise:

- Dental staff need to be trained on how to use and interpret the output of AI systems effectively.
- This requires ongoing training and support to ensure that staff can utilize the technology effectively and troubleshoot any issues.
- Investing in training and development is essential for successful AI implementation.

Regulatory and Legal Landscape:

- The regulatory and legal landscape surrounding AI in healthcare is still evolving.

- Dental practices need to stay informed about relevant regulations and ensure compliance.
- Clear guidelines and standards are needed to ensure the safe and responsible use of AI in dentistry.

Benefits of AI in Dental Practice Management

The integration of artificial intelligence (AI) into dental practice management offers a wide array of benefits that can significantly improve efficiency, patient care, and overall practice success. Here are some key advantages:

Improved Efficiency and Productivity:

- **Automation of routine tasks:** AI can automate tasks such as appointment scheduling, patient reminders, billing, insurance claims processing, and inventory management. This frees up staff time to focus on patient care and other high-value activities.
- **Optimized workflows:** AI can streamline workflows and optimize resource allocation, leading to increased productivity and reduced administrative burden.
- **Reduced waiting times:** AI-powered scheduling systems can optimize appointment scheduling, reducing patient waiting times and improving patient satisfaction.

Enhanced Patient Care and Diagnostics:

- **Improved diagnostic accuracy:** AI algorithms can analyze various data sources, including radiographs, intraoral scans, and patient medical history, to assist dentists in diagnosis, treatment planning, and risk assessment. AI can detect subtle anomalies that may be missed by the human eye, potentially leading to earlier diagnosis and improved treatment outcomes.
- **Personalized treatment plans:** AI can analyze patient data to develop personalized treatment plans tailored to each patient's specific needs and preferences.
- **Improved patient communication:** AI-powered chatbots and virtual assistants can handle routine patient inquiries, provide pre- and post-operative instructions, and send appointment reminders, improving patient communication and engagement.

Data-Driven Decision Making:

- **Valuable insights from patient data:** AI can analyze patient data to identify trends, patterns, and insights that can inform decision-making about treatment strategies, resource allocation, and practice management.
- **Predictive analytics:** AI can use predictive analytics to forecast patient volume, identify at-risk patients, and optimize inventory management.
- **Evidence-based decision making:** AI can provide dentists with access to the latest research and evidence-based guidelines, supporting informed decision-making.

Reduced Errors and Costs:

- **Minimized human error:** Automation and data analysis can minimize human error in tasks such as billing, coding, and record-keeping.
- **Reduced costs:** By reducing errors, optimizing workflows, and improving efficiency, AI can help dental practices reduce costs and improve profitability.
- **Improved fraud detection:** AI can analyze claims data to identify suspicious patterns and potential fraud, helping to protect dental practices and insurance providers from financial losses.

Improved Patient Satisfaction:

- **Personalized experiences:** AI can personalize patient communications and treatment plans, leading to increased patient satisfaction and loyalty.
- **Convenient communication:** AI-powered [21] chatbots and virtual assistants can provide patients with access to information and support around the clock, improving patient convenience and accessibility.
- **Improved treatment outcomes:** By assisting with diagnosis and treatment planning, AI can contribute to improved treatment outcomes and patient satisfaction.

Enhanced Practice Management:

- **Optimized inventory management:** AI can automate inventory management, ensuring that essential supplies are always available and minimizing waste.
- **Streamlined billing and insurance processes:** AI can automate claims processing and other billing and insurance tasks, reducing administrative burden and improving efficiency.
- **Improved marketing and patient engagement:** AI can analyze patient data to identify target audiences and personalize marketing campaigns, improving patient engagement and practice growth.

Future Works:

The field of AI in dental practice management is rapidly evolving, and several exciting avenues for future work and development are emerging. Here are some key areas where future research and innovation are likely to focus:

Enhanced Diagnostic Capabilities:

- **Integration of multiple data sources:** Future AI systems will likely integrate data from various sources, such as radiographs, intraoral scans, patient medical history, genetic information, and even real-time sensor data from wearable devices, to provide a more comprehensive and accurate assessment of patient health.
- **Improved detection of complex conditions:** AI algorithms [22] will be further developed to detect more complex dental

conditions, such as temporomandibular joint disorders (TMD), sleep apnea, and even early signs of systemic diseases that manifest in the oral cavity.

- **Development of personalized risk assessment tools:** AI can be used to develop personalized risk assessment tools that can predict a patient's likelihood of developing specific dental diseases based on their individual risk factors.

Advanced Treatment Planning and Simulation:

- **Development of AI-powered treatment planning software:** Future AI systems will likely offer more advanced treatment planning capabilities, such as automated generation of treatment options, simulation of treatment outcomes, and prediction of treatment duration and cost.

- **Integration with robotic surgery systems:** AI can be integrated with robotic surgery systems to assist dentists in performing complex procedures with greater precision and accuracy.

- **Development of personalized treatment protocols:** AI can be used to develop personalized treatment protocols that are tailored to each patient's specific needs and preferences.

Enhanced Patient Engagement and Communication:

- **Development of more sophisticated chatbots and virtual assistants:** Future AI-powered chatbots and virtual assistants will be able to handle more complex patient inquiries, provide personalized education and support, and even monitor patient progress remotely.

- **Integration with telehealth platforms:** AI can be integrated with telehealth platforms to provide remote consultations, monitor patient progress, and deliver personalized care plans.

- **Development of AI-powered patient education tools:** AI can be used to develop engaging and interactive patient education tools that can help patients better understand their oral health and treatment options.

Improved Practice Management and Operations:

- **Development of AI-powered predictive analytics tools:** Future AI systems will offer more sophisticated predictive analytics capabilities, such as forecasting patient volume, identifying at-risk patients, and optimizing resource allocation.

- **Integration with electronic health records (EHR) systems:** Seamless integration of AI systems with EHR systems will be crucial for efficient data exchange and workflow optimization.

- **Development of AI-powered decision support systems:** AI can be used to develop decision support systems that can help dentists make informed decisions about practice management, marketing, and financial planning.

Addressing Ethical and Regulatory Challenges:

- **Development of ethical guidelines and standards:** It will be crucial to develop ethical guidelines and standards for the

use of AI in dentistry to ensure responsible and equitable implementation.

- **Addressing data privacy and security concerns:** Ongoing research and development will be needed to address data privacy and security concerns related to the use of AI in healthcare.

- **Ensuring regulatory compliance:** Dental practices will need to stay informed about evolving regulations and ensure compliance with relevant laws and standards.

Conclusion

The integration of artificial intelligence (AI) into dental practice management represents a significant paradigm shift, offering transformative potential across various aspects of dental care and practice operations. This exploration has highlighted the diverse applications of AI, ranging from enhancing diagnostic accuracy and personalizing treatment plans to streamlining administrative tasks and optimizing practice management. AI [23] is not merely a technological advancement but a catalyst for positive change in the dental profession. By embracing AI and addressing its associated challenges, the dental community can unlock its transformative potential to improve patient care, enhance practice efficiency, and shape the future of dentistry. As AI technology continues to evolve, it is essential for dental professionals [24] to stay informed, adapt to new advancements, and embrace the opportunities that AI presents to provide better care for their patients and build more successful practices. The future of dentistry is increasingly intertwined with AI, and its responsible and effective implementation promises a brighter future for both dental professionals and the patients they serve.

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Conflict of Interest

No conflict of interest.

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