Generative AI in Dentistry: Transforming Patient Care and Treatment Planning

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ABSTRACT

Artificial intelligence (AI) is changing healthcare by advancing diagnostic accuracy, streamlining treatment planning, and enhancing patient care management. In dentistry, Large Language Models (LLMs) like Chat Generative Pre-Trained Transformer (ChatGPT) are proving to be invaluable for improving clinical decision-making and overall patient care.

In this paper, we explore how ChatGPT is transforming the process of decision-making in the field of dentistry by providing diagnostic assistance, individualized management plans, and educational resources. The advantages include increased efficiency, enhanced precision, and increased accessibility that makes it an essential tool in today's dental practice. Nevertheless, its application has to be coupled with professional judgment and a number of ethical issues. Adopting the use of ChatGPT in the right way in clinical practice helps dental practitioners to be in a position to provide better care to patients while upholding professional standards.

Introduction to ChatGPT in Dentistry

Advancements in AI technology have given rise to a new direction of evolution in health care, particularly in the realm of dentistry. Chat generative pre-trained transformer (ChatGPT) is one such advancement that has been trained to not only harness the power of AI but also to provide a more human touch by giving results in a conversational manner. ChatGPT, a conversational variant of Generative Pre-trained Transformer 4 (GPT-4) developed by OpenAI, is one of the milestone Large Language Models (LLMs) with billions of parameters. It is transforming dentistry by assisting with patient communication, clinical decision support, and administrative tasks. By understanding and generating human-like text, it helps dental professionals streamline their practices and improve patient care.[1] This LLM helps in landing a better clinical diagnosis by analyzing medical imaging[2], including diagnosing dental caries[3],periodontitis[4], and implantitis[5], and assisting oral and maxillofacial surgery with surgical planning.[6] Studies and systematic reviews even showcase real world implementation of ChatGPT in undergraduate dental education.[7] Chat GPT is also playing a role of an auxiliary in chronic health conditions' management.[8] Apart from clinical scenarios ChatGPT also lends a helping hand in administrative work, patient education, scientific writing and evaluation. This new revolution in data learning allows for better handling of clinical as well as non-clinical tasks, like administration; however, presents with critical concerns regarding data collection and privacy.[9] Rapid advancements in AI, including ChatGPT, are transforming dentistry by enabling more accurate, efficient, and customized care.[10] From improving diagnostics and treatment planning to enhancing patient interactions, AI is driving significant improvements in modern dentistry and paving a path for more innovations.

Enhancing Patient Communication and Education

ChatGPT is introduced as a breakthrough software for advancing patient education and communication in dentistry by clarifying complex procedures and tailoring information
to individual patient needs. Unlike conventional search engines, it provides a direct, clear and human-sounding response without the need to scrutinize multiple websites,
making it a productive and capable resource for patient education.

Gupta et al. in their studies describe the main features of ChatGPT in health literacy and publicity, highlighting its versatility in various communication scenarios.[1] Similarly, Alessandri Bonetti et al. conveys ChatGPT's supremacy over Google in generating educational materials that are more customized for patient comprehension and active involvement.[11]

An exceptionally remarkable feature of ChatGPT is to make post-operative guidance clearer, converting it into a middle school reading level while also guaranteeing its reliability and correctness. This warrants that patients from diverse academic and linguistic backgrounds can easily understand critical care guidelines, paving the way for higher compliance and superior recovery outcomes.[12] ChatGPT as a trustworthy tool for delivering evidence-based, easy to understand responses to frequently asked patient concerns about orthopedic procedures, showcasing its prospect across different medical specialties, demonstrating its potential as a multifunctional tool for patient education.[13]In dentistry, particularly, advanced models like ChatGPT 4.0 have illustrated effective diagnostic reasoning and in-depth dental understanding, making them a priceless resource for patient interactions, as well as for dental knowledge and pre-exam study.[14] The expanding acceptance of ChatGPT among healthcare professionals and students further showcases its potential. In a recent study by Tangadulrat et al, medical trainees and physicians assessed ChatGPT's role in medical practice and medical instructions. The results reinforced its valuable contribution, notably in patient teaching and clinical impact, spotlighting its ability to transform the way knowledge is communicated in healthcare establishments.[15]

Support in Clinical Decision-Making

The use of artificial intelligence in the field of dentistry, among other fields, has shown promise in assisting healthcare providers in decision-making for specific contexts. ChatGPT is one of the most prominent and capable AI tools, offering innovative solutions for decision-making and learning in clinical settings. It evaluates applications that positively impact dentistry, providing advantages while introducing significant changes for dental professionals. Due to the capability of ChatGPT in processing patient information including symptoms, medical histories, and imaging findings, it has been instrumental in the diagnosis process. For instance, the tool can output possible diseases that could be causing dental problems such as caries, periodontal diseases, or oral ulcers.[16,17] Its most helpful use, however, is in the detection of oral cancers due to its ability to detect the patterns and risk factors which may be missed during a standard examination.[16] A study showed that ChatGPT increases the probability of identifying oral cancers through patterns in the symptoms reported by the patients and the imaging scans.[16] This capability not only reduces the rate of incorrect diagnosis but also contributes to the identification of the conditions at their initial stages hence enhanced patient outcomes.[16,17]

In addition, since ChatGPT's diagnostic suggestions are derived from vast databases, it provides diagnostic suggestions that are in line with the current practice guidelines and evidence-based medicine.[18,19] However, ChatGPT is also vital in the creation of detailed treatment plans. It is especially useful for difficult cases, for example in prosthodontics or orthodontics. In particular, it helps to take into account the patient's choice, their financial status, and clinical situation to propose the most appropriate treatment options. For instance, in prosthodontics it is capable of assessing bone density, occlusion, and the aesthetic demands in order to suggest appropriate solutions. Similarly, in orthodontics it is capable of assessing cephalometric data in order to determine the best treatment plans.[20] In particular, it helps to implement these processes since they simplify the work of clinicians when it comes to decision-making. Also, its capacity in offering the cost-benefit analysis

guarantees that patients receive services that are both effective and economical.[20] It also is a great educational tool for both the dental personnel and the patient. To clinicians it offers access to guidelines, reference cases and best practice suggestions at the moment of decision making.[18] This is a useful activity for the field as it offers a constant source of information for the practitioners who want to update their knowledge base.[18,21]

Besides professional education, ChatGPT facilitates the patient's interaction. This is so because it is not always easy to explain various conditions and the treatment plans to be administered to a layman; this is something that ChatGPT does well. For instance, it can create simple descriptions of diseases, including periodontal disease or root canal treatment.[10] This increases the patient's understanding of the condition, thereby building trust and promoting active participation in the decision-making process. The most significant advantage of ChatGPT in dentistry is that it improves the performance of the practitioners. This is because it performs tasks that would otherwise occupy the clinicians' time such as data interpretation and treatment plan generation.[21] This is due to the fact that the database on which ChatGPT depends for information decreases the chances of mistakes and variations in diagnoses and treatments.[17] In addition, it is easy to use and thus can be of benefit to the practitioner as it is a walking library of medical and dental knowledge.[18,21]

However, there are some issues that need to be addressed as well. Firstly, as with all AI models, the accuracy of ChatGPT is only as good as the data that feeds it. Therefore, the suggestions made by clinicians should be compared with the clinical practice guidelines.[19] Secondly, there are ethical and privacy issues when dealing with patients' information. Thus, it is crucial to meet the requirements of data security laws, for instance, HIPAA.[19] Lastly, over reliance on AI is a risk that needs to be managed. Although ChatGPT is a powerful application it is recommended that it should be used in conjunction with the human intellect.[21]

Streamlining Administrative Tasks in Dental Practices

ChatGPT can assist dental triage and administrative teams by addressing patient's questions before their appointments, enabling patients to arrive better informed. This allows in-person consultations to be more focused and efficient.[22] For instance, in endodontics, ChatGPT-4 demonstrated an average accuracy of 57% when answering expert-level questions.[23] Information provided by patients can be utilized for improving dental administrative efficiency and help the dental professionals by narrowing down their diagnosing criteria during the initial triage by the administration and make specific decisions that would best suit the treatments needs and predict the overall prognosis for such patients. Natural language processing (NLP) techniques like keyword extraction can identify the most relevant details from patient inputs, while text summarization can condense entire patient records to emphasize on critical information within extensive entries that would otherwise require a substantial time to review and organize. For specific applications, such as predicting periodontal disease risk, rule-based algorithms have proven effective in extracting meaningful data from electronic health records (EHRs). Furthermore, dental EHRs have been extensively used to analyse and classify patients' dental histories, particularly in tracking periodontal changes over time. For instance, such systems can categorize patients into groups based on progression, improvement, or stability of periodontal conditions.[24] By using Chat GPT as a source of preceding data collection of entries made by the patients, it can be used to assist administrative tasks like daily schedule and billing. This is ideal for the betterment of the patients by providing scheduled reminders and regular check-ins by monitoring their dental health and hygiene.[25]

ChatGPT enhances patient handling by managing Frequently asked questions about office hours, services, and insurance coverage. Additionally, it sends post-treatment follow-up messages allowing for its use for dental telemedicine services.[22,23] Large language model (LLM)- based software's like ChatGPT have been tailored through continuous refinement to fulfil their potential to enhance telemedicine services in dentistry.[22] ChatGPT can be used by the administration to improve communication between healthcare professionals and patients, by providing patients with information for an increased understanding of dental care regimen by promoting and assisting better adherence to the dentist's instructions and enhancing clinical outcomes.[26]

ChatGPT/GPT-4 can accurately sense patient emotions and provide them with assurance towards any apprehensions they may have and consequently help with effective communication.[27] It has been studied through numerous demonstrations that while ChatGPT may not be as successful in providing a highly technical response, it is proficient in responding to inquiries intended to provide information to patients.[22] The next-generation models of ChatGPT have been trained to better combine clinical knowledge and interaction with dialogs. Its unique narrative interface enables innovative applications as a patient companion.[22] Language Models imbibed in ChatGPT can also engage in multilingual communication by translating text input by the patients, which is helpful to overcome language barriers in patient interactions.[22,23] Providing post operative instructions in a patient friendly language and compassionate tone helps improve the care quality and patient adherence (e.g., for medication plans, follow-up appointments, responding to feedback), thereby providing the front office with a framework to efficient patient communication. Linking LLMs to EHRs, could allow for these instructions to be given in the form of chat-based interaction to the patient providing explanations in a language of their preference.[28]

ChatGPT simplifies financial communication by providing pre-treatment cost estimates based on patients' service needs and insurance coverage details. It also aids in claim assistance, explaining insurance claims, coverage limits, and reimbursement timelines. This enhances transparency, reduces administrative workload, and ensures patients are well-informed about their financial responsibilities. ChatGPT has successfully demonstrated its ability to generate effective discharge summaries custom made with the patients detailed history, this can be useful to lessen the burden of documentation with the administration in a dental clinic.[10] The use of ChatGPT for writing pre authorization requests to insurance companies has been tested to be more efficient than a manually typed request and can prove to be highly advantageous in a dental clinic setting where communication between the triad of patient – provider and insurance company is essential.[22]

The ability of LLMs to assist healthcare professionals with routine written communications and record-keeping can significantly improve administrative efficiency. By saving time on these tasks, healthcare professionals can focus on other critical responsibilities, potentially improving patient care quality and driving cost-effectiveness in healthcare delivery.[22,23] Automated generation of referral letters for specialists, insurance companies, or business partners is another potential application of LLMs. GPT-1, the predecessor of ChatGPT, has been previously used to create clinical reports for patients. Future chatbots have incorporated contextual information, such as health insurance regulations, to address patient and providers economic and legal concerns. While all LLMs are not linked to specific knowledge databases. For instance, ChatGPT-3 generated responses solely based on prior training data without live search capabilities, Newer models like LLaMA (Large Language Model Meta AI) and ChatGPT-4 have integrated web searches into their text generation process to provide specific information to the requests made by their end users.[29]

ChatGPT can streamline administrative tasks by automating record-keeping, enabling real-time transcription of patient information during intake to minimize clerical errors and save time. It can generate customized templates for forms, consent documents, and post-operative care instructions tailored to patient profiles, improving efficiency and ensuring accurate, personalized documentation in dental practices. ChatGPT provides significant utility for dentists by streamlining administrative workflows, including automated triage, enhancing patient communication, and managing electronic health records (EHRs). By automating these processes, ChatGPT allows dentists to allocate more focus to clinical care while remaining informed about evolving health regulations and advancements. Patient record creation involves defining key fields such as demographic and medical history data, training the model to process relevant language, and integrating ChatGPT into EHR systems via Application Programming Interfaces (APIs). Additionally, ChatGPT can support triage by prioritizing cases based on urgency, enabling efficient patient care management and optimizing operational workflows.[26] Speech-based reporting has been implemented for automated dental charting[30], with early systems already commercially available. Keyword extraction and similar information-processing tools applied to clinical conversations could facilitate tasks such as generating radiological

requests, prescriptions, and referrals. Given that physicians reportedly spend nearly one-third of their time on documentation[31], such innovations hold considerable relevance. Current EHRs, often criticized for incomplete or inconsistent data, not only compromise patient care but also pose legal risks. Speech recognition systems may help address these deficiencies. Furthermore, the potential of large language models (LLMs) in dental charting has been demonstrated; for example, a fine-tuned GPT-2 model predicted the next word in dental clinical notes with an accuracy of 76%.[32] Presently, most treatment documentation relies on unstructured free-text entries. Adopting reporting standards such as the Systematized Nomenclature of Dentistry (SNODENT) could enhance interdisciplinary coordination, streamline billing, and enable efficient scientific analysis. Natural language generation (NLG) algorithms, trained to incorporate these standards, could automate the use of more than 7,000 standardized terms in SNODENT, improving the precision and utility of clinical documentation.[28]

ChatGPT offers a dynamic platform for delivering personalized, accurate dental health and hygiene information tailored to patients' specific needs. This capability not only empowers patients to make informed decisions about their oral health but also serves as a valuable educational tool for administrative functioning for dental professionals by providing access to a comprehensive body of knowledge in the field. Its integration into search engines and digital tools has revolutionized the way dental healthcare and administrative information is accessed, making it a cornerstone of modern dental education and patient engagement strategies. As highlighted in recent studies, the use of ChatGPT in dentistry demonstrates its potential to bridge gaps in information delivery, enhancing both patient care and professional development.[22,25] Chat GPT has the potential to aid with workflow optimization by assisting in the efficiency of services delivered by creating and managing to-do lists for dental staff, ensuring completion of tasks critical to the functioning of the dental clinic. As a virtual assistant to the front office, it enhances multitasking by streamlining daily operations. The support provided by ChatGPT allows dental clinics to reduce costs generated by inefficient outputs and focus more on patient care.[23] ChatGPT can be used by dentists to assist in legal and compliance tasks by keeping up with the relevant regulatory bodies. As dentistry is continuously evolving with new research shaping the future of dental advancements, ChatGPT can provide the dentists updates on the latest clinical studies, and any new medication names released by the pharmaceutical companies. This support provided by ChatGPT is a core benefit to both the patients and the dental professionals as the patient and provider relationship can mutually benefit from the most up to date regulations, drug prescriptions as well as better practice.[26]

Ethical Considerations and Challenges

The application of ChatGPT in the dental field introduces several challenges and limitations pertaining to ethics and privacy which should be studied carefully.[33,34] Few challenges include lack of knowledge in a specific field of dentistry, chances of biased content, and limited interpretability.[28,33] Ethical considerations surrounding the use of ChatGPT such as misinformation, lack of transparency, data privacy concerns, and risk of data falsification, require careful oversight and regulations must be put in place to avoid misuse.[28,33] In the discipline of dental academics, ChatGPT has been associated with concerns about academic integrity, copyright infringement, and risk of plagiarism questioning the authenticity of a student's work.[33] Although, ChatGPT can be helpful as a learning tool, too much reliance on artificial intelligence may suppress the development of critical thinking abilities of an individual.[33,35] Many observations state that electronic devices and digital technology can undermine the human's cognitive capacity and produce continuous distraction.[33,35]Additionally, these skills are vital for healthcare professionals to effectively communicate with other healthcare providers, patients and their families, which is inadvertently necessary for making informed decisions about patient care.[34]

In the context of research and dentistry, the challenges of ChatGPT are outlined as follows. Firstly, the recent version of ChatGPT has been trained on a wide-ranging database of literature resources up to September, 2023.[35] However, it may lack particular domain knowledge in medical and dental research. [35]Additionally,

ChatGPT cannot provide accurate responses based on the latest up to date research, as it only searches for answers based on what is already recorded.[35] Secondly, a potential for Bias may arise while using ChatGPT as it may present inaccurate, biased, or outdated information which is related to the quality of datasets used for training the algorithm.[34] Relying on this incomplete knowledge can sabotage patient care and clinical decision making.[34] Despite ChatGPT providing human-like responses, it can be difficult to comprehend how it attained a certain response and establish the level of confidence it holds in its response that it is accurate.[33] This flaw of limited interpretability or lack of transparency in the sense that ChatGPT behaves as a 'black box', providing insights without displaying the references- creates challenges in the field of dentistry.[33] Other setbacks of ChatGPT include the lack of incorporating human-intelligence elements such as logical thinking, emotional intelligence and understanding abstract concepts.[33,36] For example, ChatGPT may overlook the psychological and emotional intelligence elements of a patient, and fail to differentiate clinical presentations like a skilled clinician while recommending a treatment plan. Also, this might have a negative impact on patient interactions when ChatGPT cannot provide empathetic responses to patients. Addressing language barriers can be difficult, especially when working patients who don't speak English or not familiar with the technology.[35]

The ethical principles of autonomy, non-maleficence, justice, veracity, and beneficence form the foundation of medical and dental ethics, and all AI interactions with patients should be based on these principles.[33] Ethical issues such as protecting patient data (data privacy), accountability and responsibility may arise. Healthcare involves a lot of sensitive patient information such as name, gender, address, insurance details, personal relationships etc.,.[36] Medical and dental research adheres to strict guidelines like HIPAA, and ChatGPT may not accurately abide by these regulations. Thus, AI based tools like ChatGPT must be heavily monitored to protect patient confidentiality, and prevent any data breaches.[36] Likewise, using ChatGPT in clinical diagnoses or treatment decisions without considering the impact of bias and inaccurate information can have fatal consequences and the ethical concerns extend to accountability and responsibility.[37] For instance, when ChatGPT contributes to clinical decision-making and negative outcomes occur, it may be challenging to establish who should be held accountable. Patients, healthcare providers, and people who develop AI tools like ChatGPT have different levels of responsibility, and holding one accountable would create a dilemma.[37]

So, recognizing that the function of ChatGPT in clinical decision making is limited to serving as a decision-support tool rather than acting as an independent decision-maker is essential in the health sector. Therefore, using ChatGPT in this industry should take into account the potential negative outcomes for both healthcare providers and patients.[37,38] Communicating transparently about the challenges of using ChatGPT in dentistry and clarifying the accountability issues by defining the roles and responsibilities of healthcare providers and establishing guidelines and protocols are pivotal to steer away the ethical dilemmas which may arise while integrating AI into dentistry.[38] In the future, combining AI models like ChatGPT into the dental field requires unified efforts to set up best practices and ethical guidelines. Future studies should focus on developing AI models specific to the needs of medical and dental fields and evaluating their long-term effects on both student learning outcomes and patient care.[37]

Future Applications and Innovations of ChatGPT in Dentistry

A promising avenue for future research lies in developing tailored generative AI models specifically designed for dental education. These models can generate precise and relevant content when trained on curated, high-quality datasets. Successful interdisciplinary collaboration between computer scientists and medical professionals is crucial for crafting AI-driven tools that meet the unique requirements of dental education.[33] In Radiology limitations in caries and dental calculus detection through panoramic radiography may be eliminated through advanced AI techniques.[18] Due to the limitations of current imaging software, the differences between the cartilage and soft tissue cannot be easily defined, but with training machine learning models, the purpose should be achieved in the future. Multimodal learning is conducted to facilitate medical

services, which incorporates images, audio, and texts into training for a more comprehensive and robust model. However, due to limited data availability, more research still attempts to explore the merit of multi-model LLM for medical fields, especially dental clinic research. Inputting patient data is necessary for these diagnosing applications, where there is a risk of violating patient privacy and confidentiality. One possible solution to address this concern is to use offline LLM such as META LLaMA, where the LLM is run locally on the device or edge server rather than on a centralized server API Call.[39]

Combining deep learning with computer-aided design (CAD) processing to diagnose and stage periodontitis from dental panoramic radiographs has achieved high accuracy in detecting periodontal bone levels and classifying periodontal bone loss, showcasing the effectiveness of deep learning hybrid frameworks in automating the classification process of periodontitis.[40] Interpretability and transparency are essential when developing and incorporating AI models in dental education. Sharing information about the training data, challenges faced, and evaluation methods helps build trust and credibility within the medical community. High interpretability allows oral health professionals and educators to comprehend AI models' strengths and limitations, and thereby aid in informed decision making about integrating these tools into dental education curriculum and practice.[33] Implementing robust protocols, Developing Ethical Guidelines, Enhancing Data Privacy Measures and Offering ongoing education and training programs for dental professionals on the ethical implications of AI in dentistry will enhance patient trust and confidence in AI technologies.[41] The use of AI is both a significant change in itself and has the aim to improve patients' care by using a new technology that will improve diagnostic precision as well as change the workflow and the approach of treatment planning. Recent studies clearly demonstrate that AI in dentistry is poised to significantly enhance the future by offering comprehensive conveniences.[18]

Conclusion

Artificial Intelligence, in particular Large Language Models like ChatGPT, have the potential to greatly enhance dental care by improving diagnostics, treatment planning, and patient management. However, its use must be guided by professional judgment and ethical considerations to ensure optimal outcomes and uphold high standards of care. Future innovations may expand its role, offering even more personalized and efficient solutions in dentistry.

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