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Review article

Applications and potential of ChatGPT in dentistry: Scoping review of research perspectives

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Review

Abstract Since ChatGPT was released in 2022, it has been used in various settings and has rapidly been adopted worldwide. The main objective of this review was to provide a comprehensive assessment of the accuracy, reliability, usefulness, and limitations of ChatGPT in dentistry. PubMed, Scopus, and Web of Science databases were searched using the terms "ChatGPT" and "dentistry", and 63 papers were extracted. Of the 63 records identified, medical consultation and assistance were the most common, accounting for 35 of 63 records (53.8 %), followed by study assistance and confirmation tests with 16 records (24.6 %), national and specialist dental examinations with 8 records (12.3 %), and dental research with 4 records (6.2 %). Although ChatGPT can offer many possibilities in the dental field, researchers and dentists should evaluate and use it carefully because ChatGPT answers are not always reliable, and there is a possibility of information leakage. Although its limitations need to be considered, ChatGPT has the potential to revolutionize dental diagnosis, treatment, education, and research.

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Introduction

Artificial intelligence (AI) was first defined by John McCarthy in 1956 as "a computer program which seemingly exhibits intelligence".[1] This definition marked the starting point of AI research and had a major impact on subsequent technological developments.[1] AI encompasses machine learning (ML) and large-scale language models (LLMs), which have been widely studied in the medical field and also in dentistry.[2] LLMs use deep learning to achieve natural language processing (NLP) and to understand and generate text like a human.[2] Chatbots automatically use NLP and ML to respond to user questions.[2,3] Currently, a variety of language models are specialized for specific applications (see Table 1).

Open AI developed the Chatbot Generative Pre-Trained Transformer (ChatGPT), an AI-based NLP tool that was launched in November 2022.[4] Since its release, there has been a huge public response to ChatGPT, a large-scale LLM that reached 100 million users in just 2 months.[4] GPT-4, the enhanced version of ChatGPT, was released in March 2023 and can process images as well as text.[4] The latest version, ChatGPT-4o ("o" for "omni"), was released in May 2024 and is markedly superior in visual and speech understanding compared with existing ChatGPT models. Various functions have been added to each version of the system.

ChatGPT is used for a variety of applications in everyday life. It is also being used in the business sector for multiple purposes, such as correcting and proofreading texts, writing emails, preparing documents, summarizing meeting content, and generating code. ChatGPT also has applications in healthcare. In the medical field, it is increasingly used to provide fast and accurate medical information to cancer patients who are concerned about their health, as a tool during surgery, and for patient education in healthcare.[5–8] In recent years, studies using ChatGPT in the dental field have been conducted.

Several studies have been conducted on the various dental uses of ChatGPT, but these studies are limited in scope and do not provide a comprehensive overview of the potential benefits and limitations. Therefore, a comprehensive review of the available literature on the use of ChatGPT in dentistry is needed. This review aims to provide a comprehensive assessment of the accuracy, reliability, usefulness, and limitations of ChatGPT in dentistry.

Table 1 Summary of ChatGPT evolution.

Version	Release date	Key features
ChatGPT-1	June 2018	Introduced transformer architecture. Relatively small model with 117 million parameters. Basic conversational abilities.
ChatGPT-2	February 2019	Improved language generation with 1.5 billion parameters. Better at coherent and contextually relevant responses. Demonstrated significant advances over GPT-1.
ChatGPT-3	June 2020	Major leap with 175 billion parameters. Enhanced understanding and generation of text, including more complex and nuanced interactions.
ChatGPT-3.5	November 2022	Refinements over GPT-3 with 355 billion parameters and improved performance in understanding and generating text. Better at handling nuanced prompts and generating more accurate responses.
ChatGPT-4	March 2023	Further advances in understanding and generating human-like text. Improved contextual awareness and reliability. Includes multi-modal capabilities (text and image).
ChatGPT-4-turbo	November 2023	A variant of GPT-4 designed to be more cost-effective and faster, with similar or improved performance compared to the standard GPT-4.
ChatGPT-4o mini	May 2024	Optimized version of GPT-4 designed to be smaller and more efficient while maintaining high performance. Aimed at providing robust capabilities in a more compact form.

Material and methods

Protocol

A literature search was conducted based on PRISMA (preferred reporting items for systematic review and meta-analyses) guidelines in three databases (Pubmed, Scopus, and Web of Science).[9] The following search terms were used in PubMed, Scopus, and Web of Science on 25 July 2024: ("ChatGPT") AND ("Dentistry").

Eligibility criteria

The following inclusion criteria were used to select publications: (1) research articles and case report articles published in English and (2) research on the application of ChatGPT to dentistry. The following exclusion criteria were applied: (1) letters, editorials, correspondence, comments, perspectives, and review articles; (2) studies written in languages other than English; (3) research that did not apply ChatGPT in dentistry; and (4) articles where the full text was not available.

Study selection

One of the authors (M.H.) selected the studies using PubMed, Scopus, and Web of Science, and removed duplicates using EndNote X21 Clarivate Analytics software (Clarivate Analytics, Toronto, Canada). Other duplicates not initially recognized by the software were manually removed. Two reviewers (M.H. and S.K.) then independently screened the titles and abstracts of the collected studies for relevant topics. The same reviewers (M.H. and S.K.) performed another screen of the full text of the included studies from the previous step. Disagreements between the reviewers (M.H. and S.K.) were resolved by consensus.

Results

Study selection

The study selection process is summarized in Fig. 1. A total of 398 studies were retrieved in our initial search in the following databases: PubMed (n = 155), Scopus (n = 45), and Web of Science (n = 198). After removing the duplicates, 236 studies were selected. After screening of the title and abstract, and exclusion of letters, editorials, correspondences, comments, and reviews, 67 studies were selected, and 63 studies were selected for full-text eligibility assessment. Finally, considering the inclusion and exclusion criteria, 63 studies remained.

Medical consultation and assistance

Of the 63 studies, 35 studies (53.8 %) were related to medical consultation and assistance. Among these, medical consultation, which involves answering questions frequently asked by patients, was the most common, accounting for nearly half of the total (18 studies), and the fields covered included general dentistry, pediatric dentistry, periodontal disease, public health, orthodontics, oral surgery, oral cancer, and jaw deformities.[10–27] ChatGPT was often used to check clinical knowledge in areas such as oral medicine,[28,29] oral pathology,[29,30] endodontics,[31,32] periodontology,[33] orthodontics,[34–36] and oral surgery.[37–40] It was also used as an auxiliary tool in image interpretation and classification of periodontal diseases.[41,42] Silva et al. investigated the performance of the commercially available version of ChatGPT 3.5 in delineating radiolucent lesions on panoramic radiographs and establishing a differential diagnosis.[41] Tastan Eroglu et al. examined the performance of ChatGPT in classifying

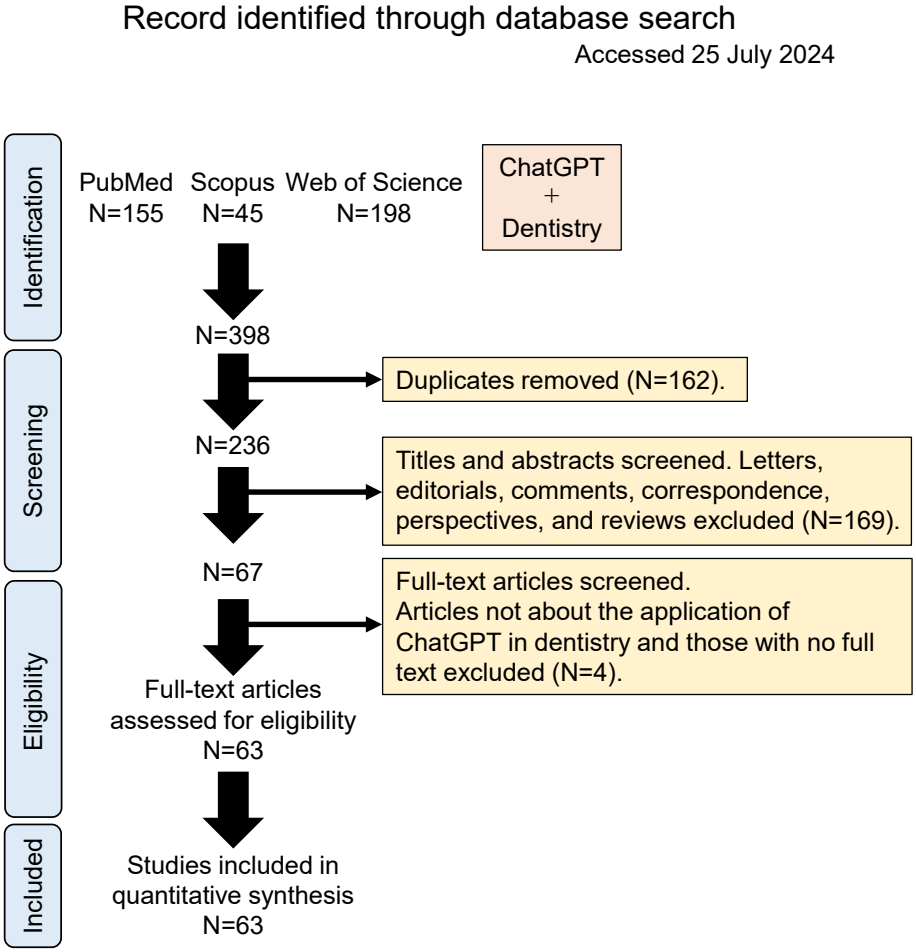

Figure 1 Record identified through database search.

periodontitis according to the 2018 classification of periodontal diseases.[42] ChatGPT has also been used in case reports; Kumari et al. reported a case study of a patient with a long-span edentulous arch by incorporating the ideas and information received from ChatGPT.[43] Additionally, Uranbey et al. reported a case in which the diagnosis of ameloblastic fibro-odontoma was assisted by ChatGPT.[44]

Study assistance and confirmation tests for dental students

The use of ChatGPT for study assistance and confirmation tests for dental students was cited in 16 of the 63 articles (25.4 %).[45–60] ChatGPT was used in dental education in six of the 16 studies, which asked ChatGPT to answer questions about dental knowledge.[45,46,48,49,57,60] ChatGPT was also used as a learning support tool in 5 out of 16 studies.[47,51,55,56,58] However, it has been reported that learning scores are higher when traditional learning methods are used rather than ChatGPT learning support tools.[51,58] Comparisons of the competence of dental students and ChatGPT in dental learning have also been examined.[52,54] It was found that university instructors were able to distinguish the reflections generated by ChatGPT from those generated by dental students.[52] ChatGPT has been applied to the development of training in medical history taking.[53] Questionnaires on ChatGPT were analyzed in two papers, which revealed that the main concerns of dental educators seeking to improve the applicability of ChatGPT were the need to provide education in its optimal and ethical use and the lack of clear guidelines and training opportunities.[50,59]

National and specialist dental examination

Of the 63 studies, 8 studies (12.7 %) were related to national and specialist dental examinations.[61–68] Of the eight, five concerned national dental examinations and three concerned specialist examinations.[62–64,67,68] The national dental examination studies were taken from four countries: Switzerland, Japan, the United States, and the United Kingdom. Among them, ChatGPT-4 was reported to perform better than ChatGPT-3.5 or ChatGPT-3.[62–64] Furthermore, in Japan, Morishita et al. and Fukuda et al. conducted research for each dental specialty using images from the national dental examination. They found that the correct response rates for the fields of anesthesiology and endodontics were 75.0 % and 71.4 %, respectively, exceeding 70 %, while the correct response rates for oral surgery, orthodontics, pediatric dentistry, restorative dentistry, and periodontics were 38.2 %, 25.0 %, 43.8 %, 30.8 %, and 23.1 %, respectively, which was below 50 %, showing that each field has its own strengths and weaknesses.[67,68]

The Iranian specialist board exam for endodontists requires a score of 70 % to pass, but ChatGPT-3.5 scored only 40 %, which did not meet the passing standard.[61] In the in-service examination administered by the American Academy of Periodontology, ChatGPT-3.5 answered 57.9 % of questions correctly, while ChatGPT-4 scored 73.6 %.[65] When answering the Integrated National Board Dental Examination (INBDE), Advanced Dental Admission Test (ADAT), and Dental Admission Test (DAT) exams, ChatGPT-4 correctly answered 88 % of the questions. ChatGPT-3.5 correctly answered 78 % of questions in the knowledge-based question section and ChatGPT-4's performance was significantly better.[66] In the case history questions section, no significant difference was found: 71 % of the answers were correct in ChatGPT-4 compared with 70 % in ChatGPT-3.5.[66]

Dental research

Four studies (6.2 %) were related to dental research.[69–72] ChatGPT was used to search for and summarize references, select journals for submission (distinguishing between predatory and legitimate journals), and create systematic reviews.[69–72] It was also used in the research fields of general dentistry, prosthetics, implants, and orthodontics.[69–72] Dashti et al. reported that the articles provided by ChatGPT were not accurately located in the database and relevant references had to be added manually to ensure accuracy.[69] In contrast, Roberts et al. reported that they were able to automate the assessment of the medical literature and identify studies that were accurately reported.[70]

Discussion

ChatGPT is widely used as a powerful tool for numerous tasks, ranging from entertainment and creativity to healthcare questions.[73] In a survey of 607 participants with at least a high school diploma, the main motivations for using ChatGPT 3.5 were to obtain information (n = 219, 36.1 %), for entertainment (n = 203, 33.4 %), to deal with problems (n = 135, 22.2 %), for health-related queries (n = 44, 7.2 %), and for brainstorming, grammar validation, and blog content creation (n = 6, 1 %).[73] In this way, the general public may also use ChatGPT to address their health concerns. We found that ChatGPT was used in four major areas in dentistry (Fig. 2): dental treatment (medical consultation and assistance), education (study assistance and confirmation tests for dental students), examinations (national and specialist dental examinations), and research (ideas and journal selection). Our findings suggest that ChatGPT has the potential to be widely used in the future. Dentistry has a significant impact on quality of life and sometimes even matters of life and death but, as in other fields, discussions about the use of ChatGPT in dentistry and the development of rules have not kept pace, highlighting the importance of taking its limitations into consideration. However, it is likely that restrictions on how ChatGPT can be used will vary depending on the purpose for which it is used, such as medical treatment or education.

ChatGPT is used in medical consultation and assistance in the medical field: it can provide quick and accurate medical information to cancer patients who are concerned about their health, it can be used as a tool during surgery, and it can provide patient education in medical care.[5–8] The present review found that medical consultation and assistance was the most commonly used application, accounting for 35 out of 63 studies (53.8 %), suggesting that this application of ChatGPT is the most widely studied in the dental field. Blease et al. investigated the use of

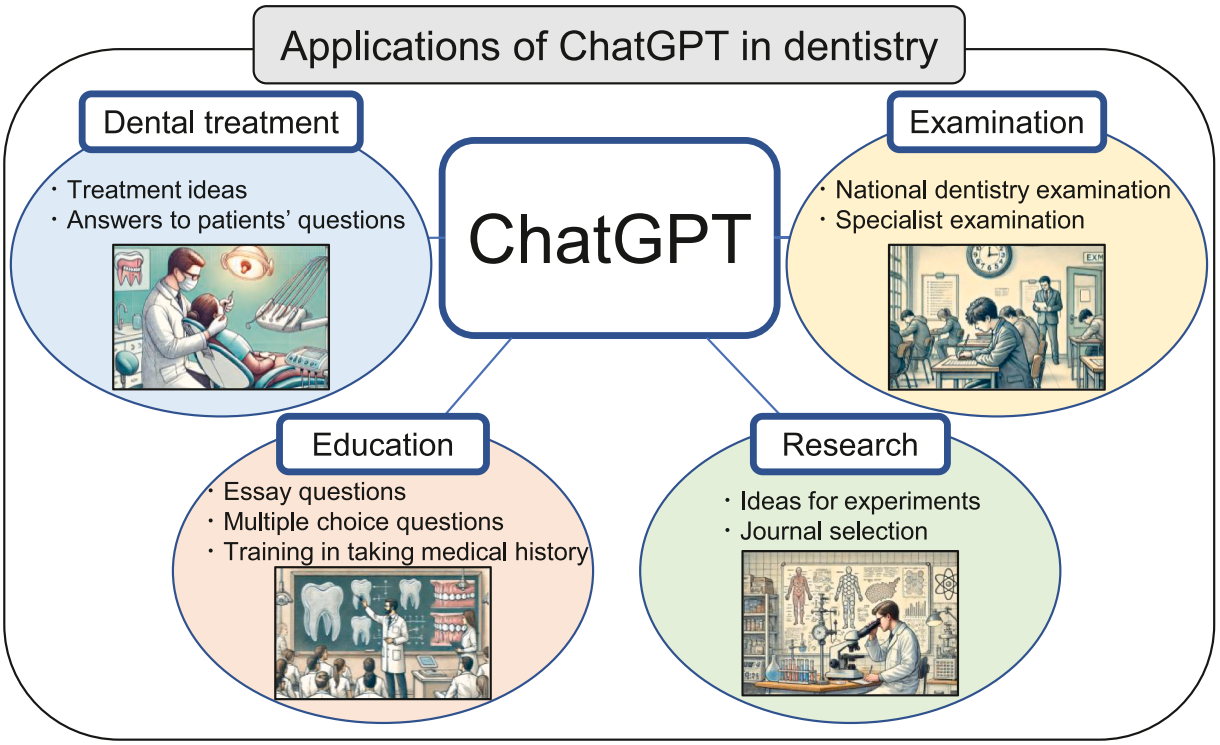

Figure 2 Application of ChatGPT in dentistry. The figure illustrates how ChatGPT is applied in dentistry, including dental treatment, education, examination and research.

chatbots by general practitioners (GPs) in the UK.[74] In their survey of 1006 GPs, 544 (54 %) were aged 46 years or older and 205 (20 %) were using generative AI tools in clinical practice. Reasons for using AI included generating documentation after patient appointments (approximately 25 %) and suggesting a differential diagnosis (approximately 25 %).[74]

Chatbots, including ChatGPT, are being used in various fields of education, including higher education, and have developed rapidly in recent years.[75–77] The use of chatbots as an educational support tool in higher education presents a variety of opportunities, including providing personalized recommendations to students, facilitating improved learning outcomes, and enabling learners to progress at their own pace.[75–77] At the same time, however, there are challenges related to ensuring academic integrity, security and privacy issues, over-reliance on artificial intelligence, adequacy of learning assessments, and accuracy of information.[75–77] Addressing these issues is essential for the effective implementation and operation of chatbots.[75–77] The use of chatbots in education has also been actively studied in the field of dentistry; this review analyzed 63 studies, 16 of which were related to education. Many of these studies identified similar problems with their use in higher education. Additionally, ChatGPT is not yet sufficiently proficient in teaching dentistry, and it has been reported that learning proficiency is higher with traditional learning methods.[51,58] As ChatGPT and other generative AI tools develop further in the future, their potential will expand greatly. However, various limitations should be recognized, such as the constant lack of depth of learning, the fear of information leakage, the need to avoid providing personal or confidential information, and copyright issues. The significance of higher education, in particular, lies in the ability to use diverse information to create one's own ideas and to generate original ideas.

Accuracy in the National Dental Examination and other dental specialty examinations was examined in 8 of 63 studies (12.7 %). Chatbot-based answers to national examinations are being developed not only in dentistry, but also in many other national examinations, including those for doctors, pharmacists, nurses, and dental hygienists.[78–81] Jin et al. conducted a systematic review of examinations in medicine, pharmacy, dentistry, and nursing, reporting that ChatGPT-3.5 had a correct answer rate of 36 %–77 %, while ChatGPT-4 had a correct answer rate of 64.4 %–100 %.[78] Furthermore, ChatGPT-4 was significantly more accurate at providing correct answers than its predecessor, ChatGPT-3.5, and showed higher proficiency in the following areas: pharmacy, medicine, dentistry, and nursing.[78] The fact that accuracy improves with each version is consistent with the research papers we extracted.

In medical research, ChatGPT is used to support the conceptualization of digital products when developing patient support tools, and for idea generation, such as creating new surgical techniques and creating new systematic reviews.[82–84] However, in this review, there were no studies on idea generation, and most of the studies focused on searching for and collecting articles during research. Although our search did not yield any results, it has been reported that ChatGPT-4o was useful in providing unpublished research ideas in the field of oral surgery in the following four areas: impacted third molars, dental implants, orthognathic surgery, and temporomandibular

disorders.[85] In the future, it may be possible to conduct research using research ideas provided by ChatGPT in this way.

The application of ChatGPT in the medical field has already been evaluated extensively across multiple aspects.[4] Notably, compared to dentistry, other medical specialties have made more advanced progress, particularly in clinical workflows such as diagnosis, decision-making, and clinical documentation, where comprehensive and multifaceted evaluations have been conducted. While dentistry also involves diagnosis and decision-making processes, the development and comprehensive evaluation of ChatGPT applications in these areas are somewhat behind those observed in other medical specialties. Nonetheless, it is expected that insights and evaluation frameworks established in general medicine will be adapted and integrated into dental clinical practice, potentially accelerating the advancement of ChatGPT applications within dentistry.

This study was conducted as a scoping review, focusing on mapping the research landscape rather than detail analyses of study designs, sample sizes, or target populations. Therefore, these analyses were not performed, which may limit the depth of interpretation. Future systematic reviews should address these aspects in detail. Additionally, some of the studies referenced did not explicitly specify the version of ChatGPT used. Consequently, precise comparison across all studies is limited by the lack of version information, which represent another limitation of this work.

In the future, accuracy and reliability will almost certainly improve with various improvements and advances. However, the application of ChatGPT in dentistry is still in an early exploratory stage and should be approached with appropriate professional oversight to avoid over-reliance or misinterpretation by users. Therefore, it is important to determine how to use and develop ChatGPT and other generative AI tools in dentistry. In doing so, we should always be aware of the limitations, such as protection of personal information, ethical issues, liability, depth of learning, and copyright issues, and comply with laws and guidelines.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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