

## Artificial intelligence (AI) role in dentistry

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### Abstract

Artificial intelligence combines the abilities of machines with human intelligence to do tasks like learning, solving problems, and making decisions in many areas. The health and medical fields, especially dentistry, are seeing more uses of AI because it helps improve the quality of care. AI helps plan treatments and care during and after procedures, making them better. For example, it can find early signs of dental problems like cavities, implants, radiography, surgeries, and diseases such as periodontal issues and oral cancers. This helps reduce harm and deaths related to these conditions. However, AI faces some challenges, like ethical concerns and issues with keeping patient information private. It must fit well with other parts of healthcare, where protecting personal data and responsibility in dentistry are very important. Also, AI is not widely used in areas that lack good technology and resources (Özden et al, 2025).

**Keywords:** Machine, Human, Intelligence, Artificial, plan, learning.

### Introduction

Artificial intelligence can adapt, organize, improve, and predict with new data, and it represents a major and important change in diagnosis, treatment planning, and therapy. AI improves the power of diagnosis across all areas of healthcare and helps in analyzing images and combining them with human skills and knowledge from different regions. The fast growth of computer power has led to better results in dentistry. AI is used for early detection of dental problems, which increases the effectiveness of care. AI tools help in making accurate diagnoses and even find oral diseases early. However, it's important to take into account each patient's individual information. Traditional methods are affected by tiredness, lack of experience, and time limits, but AI doesn't have these problems. Because of that, AI can offer more accurate, consistent,

and faster diagnostics, planning, and treatment with fewer mistakes, which can lower the time and cost of care. AI has many branches, including machine learning (ML) and deep learning (DL). Machine learning was first introduced by Simon Kovell in 1959. It is a system that can be trained with different instructions and problem-solving models to perform tasks automatically. However, it operates in a limited way, based on stored data and predicted conditions. Deep learning (DL) is a part of machine learning (ML) that uses artificial neural networks for its learning process. In contrast, strong intelligence, also called artificial intelligence, can adapt to new situations, link data, analysis predict, and provide useful recommendations based on a patient's condition. Deep learning has strong abilities to surpass existing techniques in its applications and can handle various tasks by analyzing and evaluating data from different sources, such as audio, sensors, and images. Deep learning (DL) is a type of machine learning that uses multi-layer neural networks to analyze and process data like the human brain. After receiving data, it learns and processes similar to how the brain works (figure1). This idea was first introduced by McCulloch and Walter in 1943. This type of learning uses concepts from different layers in the data processing at various levels and is considered a better alternative to traditional machine learning analysis techniques (Rodrigues , Krois, Schwendicke, 2021 and Kotha, 2024). Artificial intelligence in different parts of dentistry is strong and can be explained in detail. Artificial Intelligence (AI) for Healthcare: AI can help reduce knowledge and lower costs while increasing benefits. It is used widely in managing diseases to assess treatment results and offer personalized medicine. These advanced machine learning algorithms are strong tools that help doctors understand and analyze mental conditions. Traditional aspects of dentistry are now improved with artificial intelligence. In dentistry, AI-based diagnostic tools and patient data are widely used. These systems are mainly knowledge-based and help specialists make better decisions. This efficient technology is used for planning treatment, diagnosing, and predicting the future. Because they give clear explanations and reasons, these systems are in high demand (Farzeen. Ishag. et al, 2025), (Dias et al, 2006). AI has changed dentistry and reduced the workload for dentists. AI technology in dentistry is mainly designed to support healthcare professionals. Any computer software created to help doctors make clinical decisions and manage the knowledge needed to understand such data is called a clinical decision support system (Hoboken, 2022).



Figure1.subsets Artificial Intelligence

AI can help manage patients in the dental operating room more accurately and with fewer mistakes by using a lot of digital information. They can help with tasks before, during, and after treatment. These assistants can collect all the important dental data, manage consultations, give treatment options and advice to people with dental problems, keep a record of the patient's full oral and health history, handle financial matters, and help dentists with their assessments and treatment plans. By sharing the patient's health records and daily habits, like drinking alcohol or smoking, the assistants help create a detailed digital record for each patient. This helps dentists in treating diseases and tracking how they progress. All important steps can also be tracked digitally (Özden et al, 2025), (Schwendicke, Meyer-Luckel, 2022).

### The Role of Artificial Intelligence in Dental Education

Clinical dentistry is important for dental students to develop their skills and provide good care to patients. In the past, students learned both theoretical and practical skills through hands-on training. Recently, artificial intelligence has been used in education and teaching methods. With these new tools, real clinical conditions can be recreated in a virtual setting, allowing students to practice and evaluate their clinical and surgical methods. Students can repeat practical courses as much as needed before facing real patients, which helps them become better at their specialty and lowers the risk of mistakes. This method is more effective, reliable, and safer (Kabir et al, 2022).

### The Role of Artificial Intelligence in Radiology

Early and accurate detection of dental caries, which affects around 3 to 4 billion people each year, is one of the benefits of using artificial intelligence in radiology. Oral radiology can analyze panoramic and cone-beam computed tomography scans to diagnose diseases, detect cracked teeth, and more (Kabir et al, 2022) developed a system using artificial intelligence to identify tooth numbers in panoramic and intraoral radiographs and to create full-mouth radiographs based on the FMS (Full Mouth Series) protocol. This involves a two-step process: assigning tooth numbers to each tooth in periapical and bitewing images and organizing intraoral radiographs into a full-mouth set. The main result of this study is the introduction of a model that performs better than previous methods (like manual methods) in sensitivity and specificity. Combining this model with other diagnostic tools and electronic health record systems makes it possible to validate clinical records through deep learning-based reporting. Song et al. (Özden et al, 2025), (Song et al, 2022) assessed how effective AI based techniques are in identifying soft tissue calcifications. The study included 60 participants with salivary duct stones and carotid artery calcifications. They examined three types of calcifications: carotid artery, salivary duct stone, and lymph node calcifications. The goal was to measure how AI affects the visual interpretation skills of general dentists. As expected, using AI helped general dentists and oral medicine radiologists find more calcifications. However, it took longer for general dentists but less time for radiologists. These results show that when AI is used in radiography, panoramic



imaging can be a useful tool for screening other conditions (Sağlam et al, 2022). evaluated periapical radiographs using a U-Net-based AI model that uses convolutional neural networks. The study found that deep learning models could correctly identify periapical images, achieving score of up to 80% for sensitivity and accuracy. However, the study had some limitations, such as using only one radiography device, not having an external dataset, not involving observers from different backgrounds, and excluding several CNN models. AI allows for the integration of various imaging methods like MRI, CT scans, or cone-beam imaging with other specialized tools. For example, AI can detect even the smallest deviations in radiology (Özden et al, 2025), (Sağlam et al, 2022).

### The Role of Artificial Intelligence in Oral, Jaw, and Facial Surgery

A robotic system that increases surgical accuracy and reduces operation time. Additionally, in implant placement, it undeniably assists in predicting surgical outcomes (Özden et al, 2025). AI also plays a role in the treatment of cancerous tumors using KNN-ANN (Özden et al, 2025), (Hoboken, 2022), (Song et al, 2022), and (Bayrakdar et, 2021). Park and colleagues in 2023 compared how the identification of different implant systems from radiographic images is performed by an artificial intelligence program and dentists. They reported that a pre-trained and modified artificial intelligence program achieved statistically a higher percentage of correct results in a shorter time compared to both experienced and less experienced dentists (Chen et al, 2023). Based on the study results, artificial intelligence software was reported to be more successful in determining the height and width of bone compared to manual methods. The integration of artificial intelligence systems with human factors in implant planning can simplify, reduce costs, and make clinical work more effective. However, further comprehensive research is needed to evaluate surrounding anatomical structures using artificial intelligence system (Kabir et al, 2022).

In medical settings, image-guided procedures can be used for the successful placement of dental implants, removal of tumors and foreign bodies, and performing research, as well as tasks on the temporomandibular joint (Sukegawa et al, 2021). Even when performed by skilled surgeons, careful review of oral surgical treatments shows a much higher level of reliability compared to manual methods alone. In contrast, no significant difference in outcomes was observed between students and professional physicians (Sukegawa et al, 2021). Documentation generally indicates shorter operation times, greater intraoperative accuracy, and gentler handling of delicate tissues. Performing surgery with artificial intelligence reduces the need for potential additional procedures. Currently, with advancements in artificial intelligence studies, several robotic surgeons under the supervision of a surgeon can perform semi-automated surgical operations more efficiently, and clinical expertise helps orthognathic surgeons develop comprehensive treatment strategies that improve outcomes. When designing and fabricating splints, surgeons can significantly use AI with CT or CBCT models to automatically capture three-dimensional cranio-maxillofacial features. Therefore, three-

dimensional assessment of hard and soft tissue movements before orthognathic surgery can guide the choice of technique (Özden et al, 2025), (Sukegawa et al, 2021).

### The Role of Artificial Intelligence in Oral Cancer Diagnosis

Oral cancer is one of the least common types in terms of prevalence and incidence, but due to delays in timely diagnosis, it often has higher mortality rates compared to survivors of other types of cancer. Additionally, treatment costs and the anxiety associated with treatment should also be considered. Statistically, 2% of cancer patients have oral cancer, and 90% of patients have squamous cell carcinoma, which originates from the oral epithelium. The remaining 10% consist of a variety of malignant cancers such as salivary gland tumors within the oral cavity, melanomas, soft tissue cancers, jaw sarcomas, non-Hodgkin lymphomas, as well as tumors that have spread from other body organs (Özden et al, 2025), (Hoboken, 2022) and (Song et al, 2022). A recent systematic review of 36 studies that applied various machine learning techniques for early cancer detection showed that artificial intelligence has the potential to significantly improve the accuracy and speed of oral cancer diagnosis. However, existing evidence is insufficient to confirm any of the algorithms for detecting certain precancerous lesions (Özden et al, 2025) reported that the average sensitivity of artificial intelligence for detecting oral cancer was 83%. The average specificity in the studies was 87%, which indicates a test's ability to correctly identify patients without the disease. Artificial intelligence algorithms have also been used in several studies aimed at developing predictive models for cancer incidence. AI models have high accuracy and sensitivity in diagnosing malignant and benign cells, and they also possess deep learning capabilities in detection, support, and clinical decision-making in oncology (Kumari et al, 2022). In 2023, Park and colleagues conducted a study on identifying different implant systems from radiographic images using an AI program and dentists, reporting that the pre-trained and optimized AI program performed statistically with a higher rate of correct responses in a shorter time compared to experienced and inexperienced clinicians. Kurt Bayrakdar and colleagues evaluated the success of AI software in implant planning using CBCT in their 2021 study (Özden et al, 2025). According to the study results, AI software was reported to be more successful than manual methods in determining bone height and width. It has been reported that integrating these systems into implant planning can simplify the work of clinics. However, more comprehensive research is needed to evaluate peripheral anatomical structures using artificial intelligence systems (Özden et al, 2025), (Kabir et al, 2022). Applications of artificial intelligence in endodontics: The use of AI programs in endodontics has increased across all stages, such as diagnosis, treatment planning, and follow-up. AI programs have been examined in various areas, including determining pulp status, measuring working length, detecting periapical lesions or root fractures, evaluating root anatomy, assessing case difficulty, and predicting treatment success and prognosis. Additionally, AI programs are used to explain the operating principles of endodontic devices and are also employed in clinical education. AI programs can also be used to scan and classify lesions in the oral mucosa and identify suspicious areas. Early detection of malignant tumors in the oral region, especially in areas with limited healthcare services, with the help of AI-based

software applications, is believed to affect the incidence and mortality rates of the disease. Studies have reported that AI applications are also promising in diagnosing head and neck cancers (Sukegawa et al, 2021), (Butera et al, 2022 ).

#### The Role of Artificial Intelligence in dentistry

Chen and others studied 19 AI models for tooth detection and numbering on X-rays. They achieved over 90% accuracy. These results show that AI can help doctors make better diagnoses. Fukuda and others studied 1520 cases and found AI detected vertical root fractures with 93.9% accuracy. Other studies by Case and Arijj looked at Sjögren's syndrome and found that AI models are good at detecting lymph node issues on CT scans. Li and others studied osteoporosis using X-rays and found AI had 98.5% accuracy, just as good as experienced radiologists. AI is used in periodontics for many things like finding plaque buildup and gum disease, measuring pocket depths, checking bone loss, spotting early signs of periodontitis through X-rays, and identifying changes in bone density. It can also find people likely to get gum disease. This lets doctors take steps to stop the disease from getting worse (Ostwal et al, 2024). Several studies using large dental records looked at how AI models help predict gum disease risks by looking at age, general health, medical history, dental habits, gum condition, and blood work. AI is also used in oral, dental, and facial surgery. It helps improve X-ray quality, find cysts and tumors, and find key body parts for better surgery plans. Using AI helps make surgery more accurate and reduces risks (Zhang et al, 2021). Zhang and others studied swelling after lower wisdom tooth surgery and found AI had 98% accuracy. Their study shows AI is important for predicting how well surgeries will go (Delgado-Ruiz et al, 2024).

#### The Role of Artificial Intelligence in Periodontics

Using AI to examine dental X rays helps find early signs of gum disease. This helps avoid serious problems at different stages of checking, treating, and planning. AI can predict how gum disease might get worse and help stop it before it becomes more serious. A study by Xinya and others looked at how using smart toothbrushes with gum care guidance helped improve oral hygiene. They found that continuing to use these toothbrushes with AI support led to better results in real-life situations. Used to detect gum disease. They found that AI models can detect gingivitis and periodontitis with accuracy from 47% to 99%. However, they said these models still need improvements and could be helpful tools for dentists. the studies that used AI for periodontal care. Fukuda and others found that AI can detect vertical root fractures on X-rays with 93% accuracy (Ostwal et al, 2024). This field has been enhanced with the expansion of AI applications and innovations, from the materials used to diagnosis, treatment planning, and prosthesis fabrication. Prosthetics AI helps dental prosthetics through computer-aided design and manufacturing software, ensuring the accuracy and suitability of crowns and dental replacement devices (Paulose et al, 2022). Artificial intelligence software guides the dentist through the entire process of creating a digital mold and helps in designing and



producing a high-quality mold using AI. This significantly improves the patient's understanding of dental prostheses. The software assists in analyzing dental arch patterns and plays a role in making partial or full removable dentures (IA-Mahasap et al, 2022). Due to advances in virtual reality, the process of delivering aesthetic prostheses and meeting patients' needs has become much simpler. Gerhardt (2022) conducted research using a convolutional neural network (CNN)-based system for automatic detection and labeling of teeth in small areas and in CBCT scans, showing that AI completed the task with 99 percent accuracy in just 15 seconds, while without AI this task took an average of 98 seconds, indicating cost-effectiveness and efficiency in diagnosis. In another study, Hassan and colleagues (2021) reported that the selection of dental impression trays for arch teeth was performed with 97.5 percent accuracy by AI. In addition, the applications of artificial intelligence are also used in prosthetic dental treatments, such as evaluating tooth color, creating designs for removable prostheses, and predicting possible facial changes resulting from the use of these prostheses in patients (Kotha, 2022). AI is also used to compare the accuracy and repeatability of intraoral scanners or computer-aided design and manufacturing (CAD/CAM) systems, as well as to integrate models obtained using scanners, both of which are essential components of digital restorative dentistry. It has been shown that AI can eliminate errors that may occur during data transfer. Three-dimensional models of prepared teeth can be created, dental restorations can be designed, and these designed restorations can be milled or printed with CAD/CAM systems. In this context, AI models can be used to automate the design of dental restorations through custom reconstruction. AI applications in pediatric dentistry provide support for preventive and therapeutic oral care into adulthood. Research has shown that artificial intelligence systems can assist clinics in using behavioral guidance methods, which are important in the field of pediatric dentistry (Baydar et al, 2023). Moreover, AI helps in the early detection of plaque accumulation in primary teeth, early childhood caries (ECC), and dental anomalies. In their study, Yu and colleagues reported that a deep learning (DL) model performs similarly to a pediatric dentist in identifying plaque accumulation in primary teeth. The researchers noted that the advancement of this system enables the use of AI not only by doctors for managing children's daily dental hygiene but also by parents. Additionally, the application of machine learning in dentistry helps increase accuracy and speed up results. As a result, this facilitates the understanding of the need for dental treatment and allows for oral health assessment by dentists, parents, and even children. Applications of Artificial Intelligence in Dentistry Prosthetics in prosthetic dentistry and the integration of CAD/CAM technologies into treatment procedures have emerged as a significant advancement that enhances the effectiveness of treatments. The use of dental prosthetic services in dentistry is very common and widespread. Interestingly, artificial intelligence also contributes to the growth and transformation of restorative treatments through prosthetics. With the help of this trend, it can be used for restorations, veneers, crowns, and bridges. You have likely encountered minor errors in dental restorations and asymmetry in dental prosthetics. With the rise of artificial intelligence, these error rates decrease to the minimum possible level (Özden et al, 2025), (Baydar et al, 2023), and (Delgado et al, 2024).

Orthodontic diagnosis is a complex, multi-factor process that includes facial analysis, occlusion assessment, and the individual needs of the patient. Functional orthodontics is a time-consuming and precision-dependent procedure. A study conducted by Choi and Lee (2021) showed that the potential of artificial intelligence in orthodontics, especially in recognizing images and three-dimensional visual treatment objectives (VTO), enhances accuracy, enables automatic production, and assists in complex treatment decisions such as tooth extraction and orthognathic surgery. It reduces reliance on traditional radiography methods and brings significant advancements in intraoral scanners, three-dimensional imaging, diagnosis, and treatment planning in orthodontics. The use of artificial intelligence in orthodontics to personalize treatment is one of the latest innovations that has attracted considerable attention with the help of precise 3D images and simulated displays, 3D printing has been simplified (Dalbah, 2021). Using a unique set of the patient's dental information, this system intelligently calculates the necessary adjustments, finds the optimal solution, and identifies pressure points (Tao et al, 2022), (Hwang et al, 2021). AI-based aligners not only ensure precise treatment execution but also assist in evaluating treatment progress. They promise to reduce the time required for medications while simultaneously minimizing the number of examination visits (Tao et al, 2022). Accurate cephalometric analysis results rely on the precise and consistent identification of reference points. AI has proven effective in identifying cephalometric reference points in multiple tests. The most common method for cephalometric analysis is lateral radiography, but recently, with advances in AI, CBCT imaging has regained considerable attention (Bichu et al, 2021). In the assessment of cervical vertebrae maturation, convolutional neural network (CNN)-based models have achieved an accuracy of over 90%, as reported by Seo and colleagues (Janto, 2022). Applications of artificial intelligence in orthodontics have a wide range of uses in diagnosis, treatment planning, and clinical practice. A satisfactory orthodontic diagnosis relies on various analyses such as cephalometric analysis, dental analysis for molar relationships, tooth crowding, dental arch width, overjet and overbite, facial analysis, determination of bone maturity, and assessment of upper airway obstruction to comprehensively evaluate the overall patient profile. Visual configurations are vital tools in diagnostic and assessment stages, as they provide guidance for treatment and increase patient motivation for therapy. However, analyzing these visual configurations, such as lateral cephalograms, intraoral and facial photographs, is time-consuming when done manually and requires a significant workforce. Identifying anatomical landmarks on lateral cephalograms, in particular, depends heavily on experience and may vary among orthodontic specialists. In recent years, with advancements in artificial intelligence technology, these analyses can be produced using AI-assisted software that can utilize images, lateral and anteroposterior cephalometrics, or 3D models created by intraoral scanners. Convolutional neural network models are another example of using AI support in the diagnostic stage. The use of AI models has shown the ability to identify dental crowding and malocclusions that require orthodontic treatment through intraoral photographs. AI is also used for tooth identification in patients with cleft lip and palate (cdef) and has shown high overall sensitivity ( $0.98 \pm 0.03$ ) and high accuracy ( $0.96 \pm 0.04$ ). It was found that AI systems are effective in identifying and numbering teeth in cdef cases, but further modifications are needed to increase accuracy, especially in the cdef region. In conclusion, AI still cannot replace clinical expertise, but its role in supporting



traditional diagnostic and treatment methods is growing. Continuous advancements, supported by collaboration and rigorous validation, have improved artificial intelligence and will ensure its safe and effective use in everyday dental practice. Additionally, there have been reported cases where AI programs were used to assess the need for tooth extraction. Research has shown that AI applications are highly capable and provide remarkable accuracy in determining the need for tooth extraction (Özden et al, 2025), (Bichu et al, 2021), and (Janto et al, 2022).

### Ethical Considerations in Artificial Intelligence

Despite its broad impact on healthcare, artificial intelligence faces numerous and serious ethical challenges, such as protecting patients' legal rights, obtaining consent for data use, ensuring the safety and transparency of factors and systems, and preventing bias in AI algorithms. While AI advancements, such as neural networks, natural language processing, image recognition, and sound recognition, have transformed medicine and dentistry in various ways, they are not without drawbacks and obstacles. One example is the high initial capital costs of equipment. When applied in clinical medicine, the methods considered for admission to the medical profession have very specific severe limitations. At times, simple flowcharts and matching statistical patterns easily become uncontrollable. Algorithms often make incorrect assumptions, which leads to doubts about their responsibility in healthcare. Although artificial intelligence systems provide significant assistance in dentistry and dental education, biological processes are far more complex, and AI systems can never replace human knowledge, skills, and decision-making capacity (Özden et al, 2025), (Kabir et al, 2022), and (Mirishli, 2024).

Despite numerous studies showing the potential applications of AI in dentistry, these systems are still far from fully replacing dental specialists. AI should be regarded as an additional advantage for dentists and other professionals. The results of this review indicate that the adoption of AI-based technologies for clinical solutions and dental laboratories enables dentists to digitally replicate procedures and treatments, ensuring that data is shared throughout the digital dental process. In addition, this technology offers significant benefits in terms of accuracy and quality, as well as saving time and cost (Tabatabaian et al, 2023).

### Results

Existing articles on the applications of artificial intelligence in oral medicine cover fundamental areas such as oral cancer, lichen planus, bisphosphonate-related osteonecrosis of the jaw, odontogenic keratocysts, and the classification of oral lesions. Artificial intelligence has shown considerable potential in terms of accuracy, sensitivity, and specificity.

### Conclusion

The findings from these articles show that AI has a lot of potential to help dentists in diagnosing and treating oral diseases more accurately. While the results are encouraging, they also stress the need for more research and improvements to make the most of AI in dentistry. It also says

that AI is a useful tool, but it should support, not replace, healthcare professionals. AI explains how smart agents are made to observe and think about their surroundings, and how they can make decisions based on learning from experience to reach certain goals. There are different types of AI, like machine learning, computer vision, natural language processing, and expert systems, which together let machines mimic human thinking. Also, deep learning, which is part of machine learning, helps in making decisions and handling large datasets. It uses algorithms to create artificial neural networks with many hidden layers. Patient data is used to make better clinical decisions and improve patient results. Other advantages of AI include helping healthcare workers communicate with each other worldwide, saving time on daily tasks, setting up personalized care plans for patients, and offering remote healthcare services. Top care methods, like using AI in dental software, can help dental providers make periodontitis diagnoses more consistent and improve patient acceptance by helping them better understand their condition. Modern technology and new care methods, like using AI in dental software, can improve patient education, support better clinical decisions, increase work efficiency, and encourage teamwork among professionals. Some AI-based tools for analyzing dental images have quickly advanced AI, opening up new possibilities in dentistry and promising to change various areas of the field. Using AI also brings up ethical concerns, such as getting patients' permission to use their data, making sure data is secure and transparent, ensuring fairness and avoiding bias in AI algorithms, and protecting patient privacy. Since health data is usually complicated, private, and must follow strict laws, researchers and teachers need to work with healthcare professionals, data experts, and government bodies to ensure that AI training data is collected ethically and correctly. To stop data leaks or misuse, strong national guidelines and proper legal rules must be put in place.

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