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LITERATURE REVIEW

# EXAMINING THE IMPACT OF ARTIFICIAL INTELLIGENCE IN DENTISTRY: A COMPREHENSIVE SYSTEMATIC REVIEW

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**Abstract**

**Background:** Artificial Intelligence (AI) in dentistry has the potential to revolutionize oral healthcare by solving its inherent shortcomings.

**Aim:** To review and evaluate the body of research on artificial intelligence's use in dentistry, with a focus on how it affects treatment planning, diagnosis, and patient care in a range of dental specialties.

**Methodology:** 30 papers encompassing oral diagnosis, surgery, endodontics, prosthodontics, orthodontics, forensic dentistry, radiography, and periodontics are thoroughly examined in this review using PRISMA guidelines. The Cochrane Handbook principles were followed in the evaluation of important variables such as randomization, blinding, withdrawal/dropout rates, sample size estimation, clarity of inclusion/exclusion criteria, examiner reliability testing, pre-specification of outcomes, and bias risk. The Newcastle-Ottawa Scale (NOS) was used in quality assessment to measure bias risk and star ratings.

**Results:** The research highlight improvements in diagnosis, treatment planning, and procedural accuracy, illustrating the revolutionary effects of AI in dentistry. Applications of AI demonstrate its versatility and include automated designs, risk prediction, lesion recognition, and precision in dental operations. There is little chance of bias in randomization, intervention variations, and outcome assessments, according to the methodological evaluation, which shows excellent scientific rigor. Even though a few studies had minor issues including uneven blinding and missing data, these had no appreciable impact on the dependability of the results. Overall, the studies' consistent methodological quality highlights how AI may be relied upon to advance dental research and practice.

**Conclusion:** The transformational promise of artificial intelligence (AI) in dentistry is affirmed by this systematic study, which also supports ongoing research efforts to refine models and establish AI's position as a dependable and significant tool across a range of dental specialties. To ensure AI's smooth integration into standard dental procedures, the study emphasizes the dynamic nature of AI in dentistry and calls for ongoing research, validation, and improvement.

***Keywords:*** *Artificial Intelligence, Clinical Dental Informatics, Dentistry, Diagnostics, Machine Learning, Neural Networks (Computer).*

## INTRODUCTION

In dentistry, artificial intelligence (AI) is now used in many important areas, such as real-time patient intervention and tailored treatment planning. The considerable potential of AI in forecasting treatment results and evaluating the effectiveness of different dental therapies has been highlighted by recent studies.[1-3] The field of dentistry has greatly benefited from artificial intelligence (AI), which has shown promise in a variety of applications ranging from treatment planning to diagnostics. Current studies have demonstrated how AI subfields like deep learning can improve the detection of various dental anomalies, caries, and malocclusions, leading to a significant increase in accuracy and precision in clinical practice.[4-8]

The incorporation of convolutional neural networks (CNNs) into artificial intelligence (AI) technologies has greatly advanced the field of dentistry by enabling tasks such as caries identification, tooth segmentation, and dental composite shade determination.[5,8,9] Furthermore, AI has made it easier to streamline difficult processes like endodontic therapy and prosthodontic reconstructions, which has increased clinical efficiency and patient satisfaction.[3,10] In addition, the combination of AI-driven robotics has made it possible to conduct objective evaluations of the effects of orthognathic therapies on face aesthetics in addition to more accurate and secure dental procedures.[11-13] Even with these developments, there is still much to learn about the extensive role AI plays in dental practice, which calls for a systematic review to fully investigate the uses and results of AI in dentistry.[14] AI-driven tool integration has also transformed patient education and engagement, empowering people to make knowledgeable decisions about their dental health.[2,3,15]

### Foundation And Evolution Of AI

By enabling the simulation of human intelligence and tasks using algorithmic sequences, John McCarthy's idea of AI has significantly advanced numerous disciplines, most notably healthcare.[16] A key component of artificial intelligence, machine learning has simplified data processing without the need for explicit programming, enabling computers to learn on their own and make defensible conclusions. Because of his contributions to machine learning, artificial intelligence has advanced significantly. The idea that algorithms can learn from data and adapt to changing contexts continues to drive AI technology breakthroughs.[17] The effective integration of deep learning, a machine learning evolution, in applications such as IBM Watson, Amazon Alexa, and AlphaGo, attests to its critical role in digesting complex algorithms. Deep learning, a major advancement in the field, has enhanced AI's potential by enabling the creation of complex models that can process large datasets and extract insightful information, ultimately improving patient outcomes and healthcare practices.[1,2,18]

### AI applications in Dentistry and the growing dependence on Computer-based insights

Due to the rapid advancement of science and technology, AI-based applications such as Siri and Alexa, which are based on the core concepts of AI and its related components, have become widely used. AI was first used by John McCarthy in 1955, and its main

purpose is to create computers or software that can mimic human intellect and carry out jobs.[16,19] Machine learning is a branch of artificial intelligence that uses algorithms to forecast data from datasets so that machines may learn and solve problems on their own. Artificial neurons in neural networks process signals to simulate the functioning of the human brain. A key component of machine learning is deep learning, which uses several computing layers to improve feature recognition and automatically find patterns.[20]

Artificial intelligence (AI) has greatly improved diagnostic accuracy in the field of dentistry, which is essential for guaranteeing the best possible treatment results and exceptional patient care. AI apps are being used by dentists more and more to support clinical decision-making; recent papers have emphasized this increased reliance on computer-based insights.[20] This systematic review aims to explore the current and future applications of AI in healthcare and dentistry, highlighting its potential in influencing these domains' futures. It does this by identifying common applications of AI in dentistry and evaluating their effectiveness in diagnosis, clinical decision-making, and the prediction of treatment prognosis.

## METHODOLOGY

*Research question: "What are the impacts of artificial intelligence (AI) on dentistry, specifically regarding its applications, effectiveness in diagnosis, clinical decision-making, and treatment outcomes?"*

*Search strategy, searched databases, and keywords:* The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) criteria were followed in the conduct of this systematic review. Electronic databases including PubMed, Medline, Embase, Cochrane, Google Scholar, Scopus, and Web of Science were searched for relevant material. Articles published between January 2000 and January 2023 were included in the search. In accordance with the PICO (Population, Intervention, Comparison, Outcome) elements, a comprehensive set of keywords, such as *"artificial intelligence in dentistry," "deep learning," "machine learning," "artificial neural networks," "convolutional neural networks," and "computer-aided diagnosis,"* were used in the search (Table 1).

AI, dentistry, AI in dentistry, neural networks in dentistry, machine learning, AI dental imaging, and AI treatment suggestions were among the medical topic heading (MeSH) terms utilized in the search. The databases of the Cochrane Collaboration, ScienceDirect, Scopus, Web of Science, and PubMed/MEDLINE were searched electronically. The search approach may be improved even more by adding more pertinent keywords associated with dentistry and artificial intelligence. These might include phrases like *"computer-aided diagnosis," "oral pathology," "dental radiography," "tooth segmentation," "treatment planning," "clinical decision support," "orthodontics," "endodontics," "oral surgery," as well as "prosthodontics."* By adding these terms to the search, you may get more thorough results that address different facets of AI applications in various dental fields. By using these keywords, we hope to gather a wider range of research and publications that examine the relationship between dental practice and artificial intelligence. A thorough search for pertinent studies in the topic of artificial intelligence in dentistry is ensured by the databases listed, which include PubMed/MEDLINE, ScienceDirect, Scopus, Web of Science, and the Cochrane Collaboration. These are some of the most reliable and extensive sources for dental and medical literature (Table 1).

***Table 1.*** *Database Search Strategy for AI in Dentistry*

| Database | Keywords |
|---|---|
| **PubMed/MEDLINE** | *"Artificial intelligence" AND "dentistry"; "AI in dentistry"; "neural networks" AND "dentistry"; "machine learning" AND "dentistry"; "AI dental imaging"; "AI treatment recommendations"; "computer-aided diagnosis" AND "dentistry"; "oral pathology"; "dental radiography"; "tooth segmentation"; "treatment planning"; "clinical decision support"; "orthodontics"; "endodontics"; "oral surgery"; "prosthodontics"* |
| **ScienceDirect** | *"Artificial intelligence" AND "dentistry"; "AI in dentistry"; "neural networks" AND "dentistry"; "machine learning" AND "dentistry"; "AI dental imaging"; "AI treatment recommendations"; "computer-aided diagnosis" AND "dentistry"; "oral pathology"; "dental radiography"; "tooth segmentation"; "treatment planning"; "clinical decision support"; "orthodontics"; "endodontics"; "oral surgery"; "prosthodontics"* |
| **Scopus** | *"Artificial intelligence" AND "dentistry"; "AI in dentistry"; "neural networks" AND "dentistry"; "machine learning" AND "dentistry"; "AI dental imaging"; "AI treatment recommendations"; "computer-aided diagnosis" AND "dentistry"; "oral pathology"; "dental radiography"; "tooth segmentation"; "treatment planning"; "clinical decision support"; "orthodontics"; "endodontics"; "oral surgery"; "prosthodontics"* |
| **Web of Science** | *"Artificial intelligence" AND "dentistry"; "AI in dentistry"; "neural networks" AND "dentistry"; "machine learning" AND "dentistry"; "AI dental imaging"; "AI treatment recommendations"; "computer-aided diagnosis" AND "dentistry"; "oral pathology"; "dental radiography"; "tooth segmentation"; "treatment planning"; "clinical decision support"; "orthodontics"; "endodontics"; "oral surgery"; "prosthodontics"* |
| **Cochrane Collaboration** | *"Artificial intelligence" AND "dentistry"; "AI in dentistry"; "neural networks" AND "dentistry"; "machine learning" AND "dentistry"; "AI dental imaging"; "AI treatment recommendations"; "computer-aided diagnosis" AND "dentistry"; "oral pathology"; "dental radiography"; "tooth segmentation"; "treatment planning"; "clinical decision support"; "orthodontics"; "endodontics"; "oral surgery"; "prosthodontics"* |

**Selection criteria**

*Inclusion criteria:*

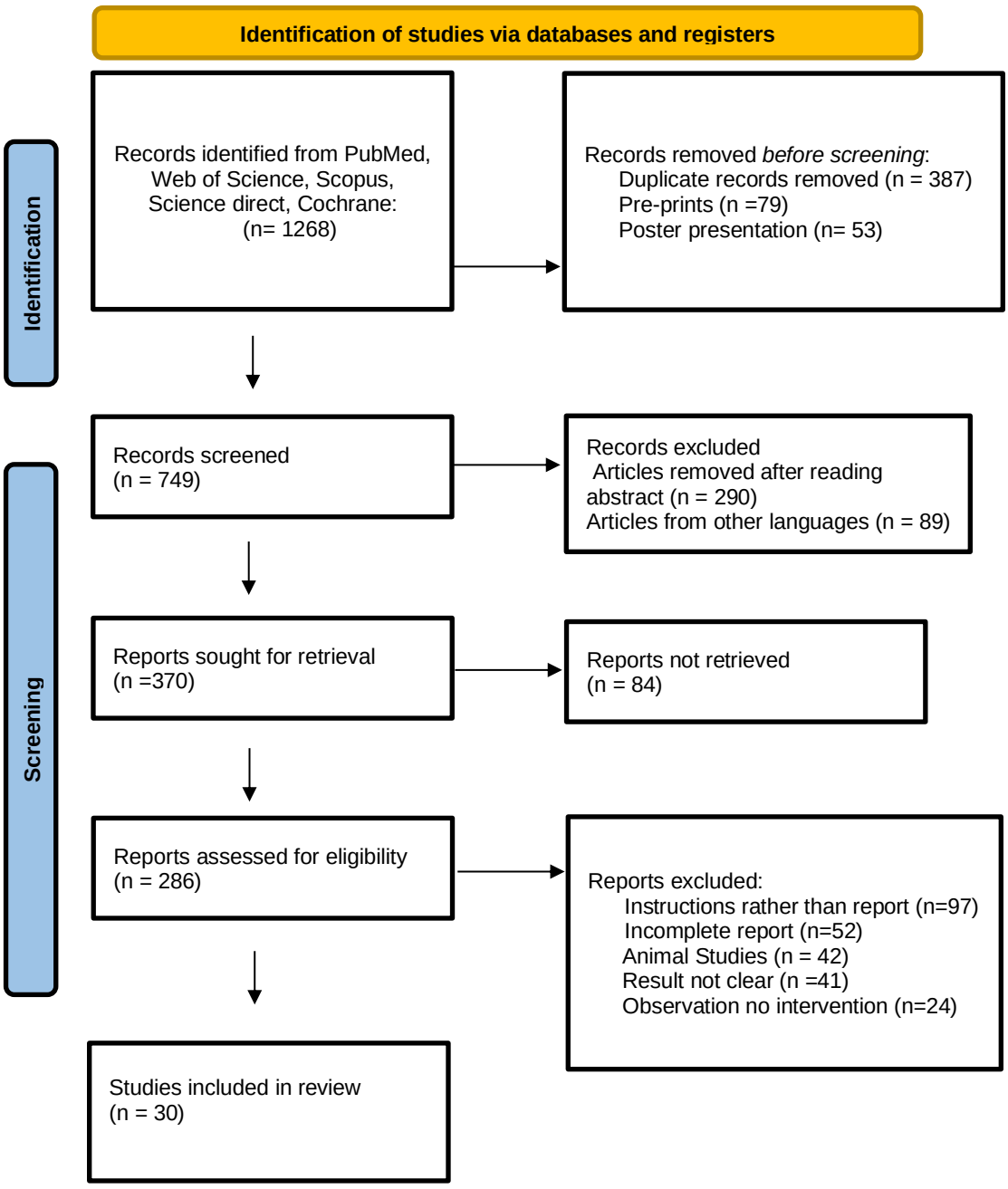
- The usage of AI in dentistry must be the main topic of the essay.
- The research must yield quantifiable, predictive, or measurable results.
- The datasets used to evaluate the model must be well documented.

*Exclusion criteria:*

- Articles not about artificial intelligence or its uses in dentistry.
- Unpublished works and articles that are not available in full text.
- Articles written in languages other than English.
- Research using simply abstracts and no full text versions.

*Data extraction and quality assessment:* Out of a total of 1268 articles only 30 were found to be inclusive in the present review and were analyzed further as is depicted by the PRISMA chart (Figure 1). These 30 publications were ultimately chosen for qualitative synthesis after a thorough evaluation based on the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) recommendations led to the exclusion of 3 more studies. A thorough analysis of the chosen publications was carried out, accounting for the articles' dates of publication, to chart the evolution of AI trends in dentistry during the last 20 years.

***Figure 1.*** *PRISMA Flowchart for the review*




*Risk of bias assessment:* For case-control studies, the Newcastle-Ottawa quality assessment scale (NOS) was employed, considering crucial quality analysis factors such as patient randomization, blinding protocols, withdrawal/dropout reporting, and sample size estimation implementation. Based on the predefined criteria, each study was categorized as having a low, medium, or high risk of bias.

*Data synthesis:* A meta-analysis was not carried out because of the variability of the variables and outcomes in the studies that were chosen. Rather, a thorough qualitative synthesis was carried out to offer a comprehensive picture of AI's influence on dentistry, assessing its possible effects on patient care and clinical practice.

***Table 2.*** Summary of Studies on Artificial Intelligence Applications in Dental Research

| Sl no. | Author/ year | Study design | Study groups | Applications | Assessment techniques | Outcome/ inference |
|---|---|---|---|---|---|---|
| 1. | Edinger DH et al. (2004)[21] | Experimental Study | Patients undergoing condylar movements reproduction | Reproduction of condylar movements | Robotic system accuracy | Preliminary report on the accuracy of the robotic system |
| 2. | Meissner et al., (2005)[22] | Clinical Study | Participants using calculus-detection device | Calculus detection | Analysis of handling-relevant factors | Assessment of factors influencing calculus-detection device behavior |
| 3. | Meissner et al., (2006)[23] | Clinical Study | Patients with periodontal conditions | Calculus detection | Smart ultrasonic device | In vitro analysis of calculus detection with a smart ultrasonic device |
| 4. | Kositbowornchai et al., (2006)[24] | Experimental Study | Participants with simulated dental caries | Dental caries detection | Artificial neural network | Detection of simulated dental caries using an artificial neural network |
| 5. | Devito et al., (2008)[25] | Clinical Study | Participants with proximal dental caries | Dental caries diagnosis | Artificial multilayer perceptron neural network | Diagnosis of proximal dental caries using a neural network |
| 6. | Saghiri et al., (2012)[26] | Cadaver Study | Cadavers | Apical foramen localization | Artificial neural network | Evaluation of the reliability of neural network in locating minor apical foramen |
| 7. | Wang et al., (2014)[27] | Clinical Study | Participants requiring tooth crown preparation | Tooth crown preparation | Robotic system for tooth crown preparation | Automatic tooth crown preparation using a robotic system |
| 8. | Otani et al., (2015)[11] | In vitro Study | Dental specimens for laminate veneers | Tooth preparation accuracy and precision | Automated robotic tooth preparation system | Evaluation of accuracy and precision of robotic tooth preparation system |
| 9. | Li et al., (2015)[14] | Experimental Study | Dentistry patients | Color matching prediction | Genetic algorithm and backpropagation neural network | Prediction in computer color matching of dentistry using a neural network |
| 10. | Deniz Arisu et al., (2018)[9] | Clinical Study | Patients receiving composite restorations | Vickers hardness ratio assessment | Artificial neural network | Determination of composite parameters' effect on Vickers hardness ratio |
| 11. | Lee et al., (2020)[8] | Clinical Study | Patients with dental caries | Caries detection and diagnosis | Deep learning-based convolutional neural network | Detection and diagnosis of dental caries using a neural network algorithm |
| 12. | Kim et al., (2018)[28] | Clinical Study | Patients undergoing dental extraction | Osteonecrosis prediction | Machine learning model | Prediction of osteonecrosis occurrence post dental extraction |
| 13. | de Dumast et al., (2018)[29] | Web-based Study | Patients with temporomandibular joint osteoarthritis | Osteoarthritis classification | Neural network-based system | Classification of temporomandibular joint osteoarthritis using a web-based system |
| 14. | Sorkhabi & Saadat Khajeh, (2019)[30] | Experimental Study | Patients undergoing alveolar bone density assessment | Bone density classification | 3-D deep convolutional neural network | Classification of alveolar bone density using a neural network |
| 15. | Bouchahma M, (2019)[5] | Clinical Study | Patients with dental decay | Treatment prediction | Deep convolutional neural network | Dental decay treatment prediction using a neural network |
| 16. | Ekert et al., | Clinical Study | Patients with | Lesion detection | Deep learning | Radiographic detection of |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (2019)[6] | | apical lesions | | system | apical lesions using deep learning |
| 17. | Yamaguchi et al., (2019)[31] | Clinical Study | Patients with CAD/CAM composite resin crowns | Debonding prediction | Artificial intelligence | Prediction of debonding of CAD/CAM composite resin crowns using AI |
| 18. | Patcas, Bernini, et al., (2019)[12] | Clinical Study | Patients undergoing orthognathic treatment | Facial attractiveness assessment | Artificial intelligence | Assessment of treatment impact on facial attractiveness and estimated age |
| 19. | Patcas, Timofte, et al., (2019)[32] | Clinical Study | Patients with cleft lip and palate | Facial attractiveness comparison | Artificial intelligence-based scoring | Comparison of facial attractiveness scoring methods |
| 20. | Hung et al., (2019)[33] | Clinical Study | Elderly patients | Root caries diagnostic prediction | Machine learning model | Diagnostic prediction of root caries using machine learning |
| 21. | Sornam & Prabhakaran, (2019)[34] | Experimental Study | Patients with dental caries | Caries classification | Artificial bee colony optimization | Dental caries classification using a neural network and optimization approach |
| 22. | Setzer et al., (2020)[35] | Clinical Study | Patients with periapical lesions | Lesion detection | Computer-aided diagnosis system | AI-based detection of periapical lesions in cone-beam CT images |
| 23. | Cantu et al., (2020)[36] | Clinical Study | Patients with caries lesions | Lesion detection | Deep learning approach | Detection of caries lesions of different radiographic extension using deep learning |
| 24. | Aliaga et al., (2020)[37] | Clinical Study | Patients with dental panoramic radiographs | Osteoporosis detection | Mandibular indices computation | Computation of mandibular indices for early osteoporosis detection |
| 25. | Cui et al., n.d.(2021)[38] | Clinical Study | Patients undergoing tooth extraction | Decision support model | Electronic dental records analysis | Development of a clinical decision support model for tooth extraction therapy |
| 26. | Vranckx et al., (2020)[39] | Clinical Study | Patients with molar angulation issues | Molar eruption prediction | AI-driven measurements | AI-based prediction of third molar eruption on panoramic radiographs |
| 27. | Lee et al., (2020)[40] | Clinical Study | Patients with TMJ issues | TMJ osteoarthritis detection | Artificial intelligence | Automated detection of TMJ osteoarthritis using AI |
| 28. | Kuwada et al., (2020)[7] | Clinical Study | Patients with impacted supernumerary teeth | Impacted tooth detection and classification | Deep learning systems | Detection and classification of impacted supernumerary teeth using deep learning |
| 29. | Abdalla-Aslan et al., (2020)[4] | Clinical Study | Patients with dental restorations | Restoration detection and classification | Machine learning system | Automatic detection and classification of dental restorations using AI |
| 30. | Takahashi et al., (2021)[13] | Clinical Study | Patients requiring partial dentures | Denture designing system | Convolutional neural network | Designing of partial dentures using a neural network-based system |

## RESULTS

Table 2 lists 30 research studies on the use of AI in dentistry, illustrating a range of methodologies. Early research concentrated on robotic systems for precision in laminate veneers,[11] dental crown preparation,[27] and condylar movement reproduction.[21] Calculus identification,[22,23] dental caries detection,[24,2533] and apical foramen localization have all benefited greatly from neural networks.[26] Predictive applications of AI have also been used for molar eruption,[39] crown debonding,[31] and osteonecrosis risk post-extraction.[28] Machine learning models have shown promise in the classification of restorations,[4] lesion identification,[35,36] and root caries

prediction.[33] Diagnoses of TMJ osteoarthritis,[40] osteoporosis identification using radiographic indices,[37] and alveolar bone density assessment all benefited from deep learning.[30] Additionally, AI systems improved dental aesthetics by using face attractiveness scoring for cases with cleft lip/palate and orthognathic therapy.[12,32] New methods include automated denture design utilizing neural networks,[13] computerized dental records for decision-making,[38] and genetic algorithms for color matching.[14] These developments demonstrate how AI is revolutionizing dental diagnosis, treatment planning, and procedure accuracy.

The included research' methodological evaluation demonstrates their commitment to scientific rigor. Randomization was applied similarly across all studies to guarantee fair distribution and reduce selection bias. Blinding, which is essential for minimizing observer and participant bias, was reported in several studies, including those by Li et al.,[14] Kim et al.[28] and Hung et al.[33] Nevertheless, none of the studies explicitly addressed participant withdrawals, which can create attrition bias and affect the reliability of the findings. Consistent inclusion and exclusion criteria ensured relevant participant selection, as per studies such as Edinger et al.[2] and Meissner et al.[22]. Predetermined expected outcomes, which indicate clearly stated study aims, were a common feature of all the trials. Each study received a rating of "low risk of bias," indicating that their methodological designs were suitable. The lack of withdrawal reporting and inconsistent blinding were two limitations that did not significantly affect the studies' reliability.[22,26] Artificial intelligence's contribution to the improvement of dental research is further reinforced by the consistent methodological quality of these investigations, which validates the outcomes.[5,6,12,37]

*Risk of Bias assessment:* The risk of bias for the included studies is assessed in detail in Figure 2, which is divided into five domains: D1 (bias resulting from the randomization process), D2 (bias resulting from deviations from the intended intervention), D3 (bias resulting from missing outcome data), D4 (bias in outcome measurement), and D5 (bias in selecting the reported result). An overall assessment is given for each domain, which is rated as low risk (green), moderate concerns (yellow), or high risk (red). Most trials demonstrated low risk for D1, pointing to suitable randomization techniques and hidden allocation. Studies like Meissner et al.[22], which sparked concerns, and certain others that lacked sufficient randomization details, like Patcas, Bernini, et al.,[12] are exceptions. Most studies in D2 indicated low risk, and there were very few departures from the planned interventions. Some studies, like Yamaguchi et al.[31] and de Dumast et al.,[29] raised some concerns since they provided insufficient information about the management of interventions. Mixed results were emphasized by D3, which assessed bias resulting from missing data. Studies like Meissner et al.[2] and Deniz Arisu et al.[9] demonstrated significant risk because of insufficient reporting, but most studies maintained a low risk by successfully correcting missing data. Because most studies used consistent and dependable measurement techniques, D4, which focused on measurement bias, showed a pattern that was primarily low-risk. However, a few instances where measuring techniques were not specifically described raised minor issues. In D5, there was very little selection bias in the results reported across studies. The robustness of findings was enhanced by pre-specification of outcomes in procedures, as demonstrated by research such as Takahashi et al.[13] and Abdalla-Aslan et al.[4] Overall, most studies maintained low risk throughout all five categories, guaranteeing dependable results and great methodological quality, even when some showed high risk or concerns in particular domains. This strengthens the validity of the results of the systematic review.

***Table 3.*** *Summary of the methodological assessment of the included studies in the review*

| Sl no. | Author/year | Randomization | Blinding | Withdrawal mentioned | Inclusion / exclusion criteria | Expected outcomes prespecified | Quality of study / risk of bias assessment |
|---|---|---|---|---|---|---|---|
| 1. | Edinger DH et al. (2004)[21] | Yes | Yes | No | Yes | Yes | Low |
| 2. | Meissner et al., (2005)[22] | Yes | No | No | Yes | Yes | Low |
| 3. | Meissner et al., (2006)[23] | Yes | No | No | Yes | Yes | Low |
| 4. | Kositbowornchai et al., (2006)[24] | Yes | No | No | Yes | Yes | Low |
| 5. | Devito et al., (2008)[25] | Yes | No | No | Yes | Yes | Low |
| 6. | Saghiri et al., (2012)[26] | Yes | No | No | Yes | Yes | Low |
| 7. | Wang et al., (2014)[27] | Yes | No | No | Yes | Yes | Low |
| 8. | Otani et al., (2015)[11] | Yes | No | No | Yes | Yes | Low |
| 9. | Li et al., (2015)[14] | Yes | Yes | No | Yes | Yes | Low |
| 10. | Deniz Arisu et al., (2018)[9] | Yes | No | No | Yes | Yes | Low |
| 11. | Lee et al., (2020)[8] | Yes | Yes | No | Yes | Yes | Low |
| 12. | Kim et al., (2018)[28] | Yes | Yes | No | Yes | Yes | Low |
| 13. | de Dumast et al., (2018)[29] | Yes | No | No | Yes | Yes | Low |
| 14. | Sorkhabi & Saadat Khajeh, (2019)[30] | Yes | Yes | No | Yes | Yes | Low |
| 15. | Bouchahma M, (2019)[5] | Yes | Yes | No | Yes | Yes | Low |
| 16. | Ekert et al., (2019)[6] | Yes | Yes | No | Yes | Yes | Low |
| 17. | Yamaguchi et al., (2019)[31] | Yes | No | No | Yes | Yes | Low |
| 18. | Patcas, Bernini, et al., (2019)[12] | Yes | No | No | Yes | Yes | Low |
| 19. | Patcas, Timofte, et al., (2019)[32] | Yes | No | No | Yes | Yes | Low |
| 20. | Hung et al., (2019)[33] | Yes | Yes | No | Yes | Yes | Low |
| 21. | Sornam & Prabhakaran, (2019)[34] | Yes | Yes | No | Yes | Yes | Low |
| 22. | Setzer et al., (2020)[35] | Yes | Yes | No | Yes | Yes | Low |
| 23. | Cantu et al., (2020)[36] | Yes | Yes | No | Yes | Yes | Low |
| 24. | Aliaga et al., (2020)[37] | Yes | Yes | No | Yes | Yes | Low |
| 25. | Cui et al., n.d.(2021)[38] | Yes | Yes | No | Yes | Yes | Low |
| 26. | Vranckx et al., (2020)[39] | Yes | Yes | No | Yes | Yes | Low |
| 27. | Lee et al., | Yes | Yes | No | Yes | Yes | Low |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (2020)[40] | | | | | | |
| 28. | Kuwada et al., (2020)[7] | Yes | Yes | No | Yes | Yes | Low |
| 29. | Abdalla-Aslan et al., (2020)[4] | Yes | Yes | No | Yes | Yes | Low |
| 30. | Takahashi et al., (2021)[13] | Yes | Yes | No | Yes | Yes | Low |

***Figure 2.*** *Risk of bias assessment based on the New Castle Ottawa scale for clinical studies*

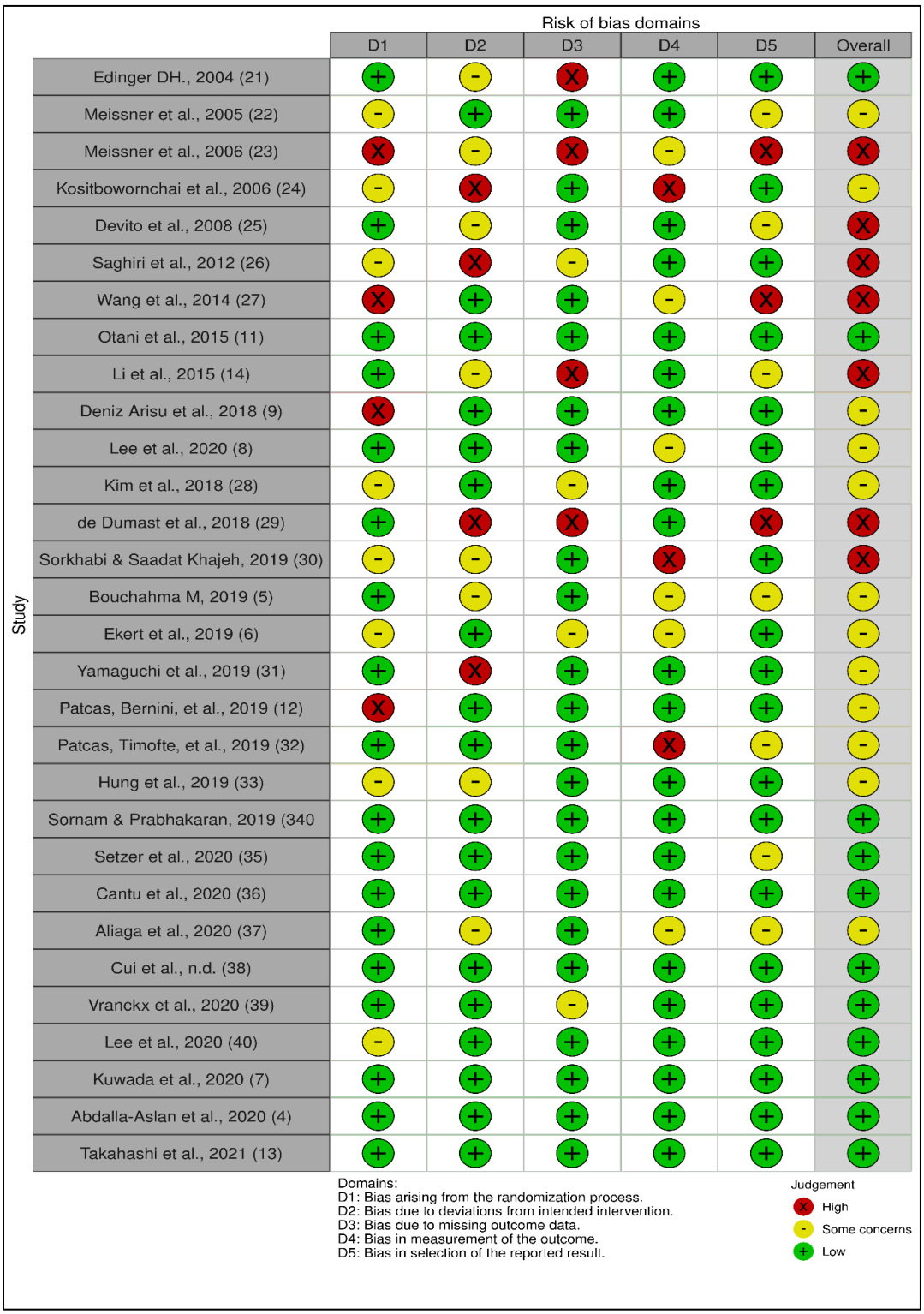


***Table 4.*** *List of articles excluded from the review analysis and reason for the exclusion*

| Title of the study | Reason for the elimination |
|---|---|
| Ayad et al., (2023)[15] | Study was about patient's perspective and study was a survey |
| Carrillo-Perez et al., (2022)[18] | review article |
| Chen et al., (2020)[1] | review article |
| Deniz Arisu et al., (2018)[9] | Invitro study |
| Gould, (2002)[41] | Study was out of the inclusion period |
| Khanagar et al., (2021)[20] | Systematic review |

## DISCUSSION

Artificial intelligence (AI) digital systems have clearly had a revolutionary impact on dentistry.[42] Dentistry has seen encouraging advancements and widespread integration within the field of artificial intelligence modalities, such as machine learning, deep learning, cognitive computing, computer vision (capable of identifying content in images and videos), and natural language processing (capable of both producing and analyzing human speech through machines.[43] A new age in dental restoration has been brought about by the development of AI, which offers improved alternatives with longer shelf lives as well as better functionality and aesthetics.[11,31] By utilizing the experience and abilities of dental professionals, the use of AI models is significantly increasing procedure efficiency and accuracy.[44]

AI technology integration has not only transformed healthcare procedures but also promoted more productive interprofessional and clinician-patient relationships. These cutting-edge strategies have given dental students new opportunities and distinctive research-based learning experiences. Additionally, the information gathered by AI systems can be applied to forensic and epidemiological settings with surprising efficacy.[2,3] Many research projects have been undertaken worldwide to investigate the uses, advantages, and comparative evaluations of AI with respect to human abilities in dentistry. The goal of this systematic review is to shed light on the significant impact artificial intelligence (AI) has had on the field of dentistry by examining the calibre and findings of studies examining various AI approaches and analyses.

The thorough analysis of numerous studies has shed light on the wide range of uses of artificial intelligence (AI) in dentistry, highlighting its numerous advantages that might greatly simplify dentists' workflow. Remarkable results suggest that artificial intelligence has great potential in many areas of dentistry.

Neural network screening for precancerous diseases and mouth cancer is one well-known use. Enhancing the early diagnosis of potentially critical oral health concerns, this skill is a crucial breakthrough. AI has proven to be a diagnostic powerhouse in detecting osteonecrosis linked to bisphosphonates, an important finding that is invaluable for making well-informed decisions prior to tooth extraction surgery. It offers a comparative advantage over conventional techniques like magnetic resonance imaging when evaluating cervical lymph node metastases of cancer.[28,41] It has been integrated into more complex methods like computer color matching (CCM), which guarantees accurate color matching for dental restorations. Concurrently, the clinical crown production process using an automated laser ablation system highlights the adaptability of AI applications in different dental procedures and highlights how it can improve accuracy and productivity.[14,27]

However, direct comparisons are difficult due to the variety of approaches used in these investigations. The complexity of synthesizing findings is increased by the diversity in data collecting and the development of AI techniques. Despite these challenges, the general agreement indicates that AI models have a beneficial effect on assisting dental diagnoses. AI can reduce human error and improve treatment planning by giving dentists sophisticated tools for interpreting dental irregularities. This research highlights the critical role that computer-based neural networks play in enhancing dental practitioners' decision-making

processes, pointing to a future in which AI works in harmony with dentists to improve diagnostic precision and care standards.

According to the current evaluation, artificial intelligence (AI) is a solid and trustworthy technology with a wide range of dental applications. AI is particularly useful in evaluating dental caries depth, identifying apical lesions, estimating working length, categorizing dental arches, segmenting teeth, identifying osteoarthritis in the temporomandibular joint (TMJ), and identifying osteoporosis in the jaws early on using panoramic radiographs.[5,6,8,13,37] Rekow, 2020 demonstrated the applicability of AI in a variety of dental care domains by employing a machine-learning algorithm to identify and categorize dental restorations on panoramic photographs.[45]

Novel methods such as the application of "DetectNet and AlexNet" showed promise in the classification of impacted supernumerary teeth on panoramic radiographs in the maxillary incisor area.[7] Voice commands were first developed by Drevenstedt et al., 2005 to capture patient history and data, provide recommendations during dental operations, schedule appointments, and remind patients to get regular checks and essential consultations.[46] When it came to diagnosing dental caries, artificial neural network (ANN) models especially those that included bitewing photographs showed excellent accuracy (97.1%), precision (95.1%), specificity (94.3%), and sensitivity (85%–99.6%).[36] Similarly, Sornam & Prabhakaran, 2019used the "back-propagation neural networks" (BPNN) AI model to classify dental caries with an accuracy range of 85 to 100%.[34]

The study notes that methodological variations make it difficult to compare these studies. Despite the encouraging results, the review points out many drawbacks, such as the potential for bias in the evaluated literature. Consideration must be given to several factors, including system complexity, costs, changes in equipment, and the amount of training needed for each AI model. The study highlights that to fully utilize AI in dentistry, more investigation, exposure, and application is necessary. It also draws attention to the current ethical and technical difficulties, highlighting the necessity of continual efforts to resolve these problems and realize the revolutionary potential that artificial intelligence holds for the dental industry. Looking ahead, AI-based comprehensive care systems are expected to bring about a significant revolution in the dental field. It is expected that these systems will analyze enormous volumes of big data, including pertinent information and faciodental images. AI models are anticipated to be essential in providing doctors with dependable data, optimizing the clinical decision-making process, and advancing cutting-edge dental research, patient care, and innovation.

It is anticipated that the use of AI and machine learning would result in the automation of several dental procedures, such as oral rehabilitation, smile design, and aesthetic assessment. The gradual incorporation of AI into dental practice is anticipated to become necessary, notwithstanding the potential early hurdles associated with adapting to such developments. The use of AI may affect patient demand for this cutting-edge technology. Artificial intelligence (AI) has shown to be a useful tool in dentistry because of its capacity to reason and carry out tasks in the most efficient way possible to accomplish objectives. This automated model demonstrates how artificial intelligence (AI) can improve productivity, accuracy, and overall dental care outcomes by managing jobs that range from simple to complicated. The incorporation of AI is anticipated to usher in a new era of sophisticated, data-driven, and patient-centered dentistry practices as the discipline continues to develop.

## CONCLUSION

With AI becoming widely used in dentistry, oral healthcare could undergo a revolutionary change as major flaws in conventional dental methods are addressed. This systematic analysis confirms that AI techniques provide dental professionals with a variety of benefits, including increased chairside efficiency, streamlined processes, infection control, and accurate, high-quality treatment delivery. AI is becoming recognized as a dependable modality for a variety of dental specialties, including radiology, periodontics, prosthodontics, orthodontics, endodontics, forensic dentistry, and oral diagnosis. Notably, AI shows efficacy in patient diagnosis, clinical decision-making, and predicting dental outcomes. Even with these developments, it is important to recognize that AI in dentistry is still developing and will require further investigation before a complete evaluation of its clinical efficacy can be made. Subsequent research

endeavours ought to concentrate on improving the AI models, incorporating them more effectively into standard dentistry procedures, and assessing the enduring effects on patient results. The advancement of AI technology and its smooth integration into the larger dental care environment will be facilitated by ongoing research and validation of its applications, which will ultimately lead to better oral health results.

## DECLARATIONS

***Conflicts of interest and financial disclosures***

The author declares that he has no conflict percent and there was no external source of funding for the research in question.

***Ethical approval***

The study was approved by the Institutional Ethics Committee and was conducted in accordance with the Declaration of the World Medical Association.

***Informed consent***

Informed consent was obtained from all individual participants included in the study.

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