OPEN ACCESS

Saudi Journal of Medicine
Abbreviated Key Title: Saudi J Med
ISSN 2518-3389 (Print) | ISSN 2518-3397 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

A Review: Impact of Artificial Intelligence on Restorative Dentistry in Recent Times

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DOI: 10.36348/sjm.2023.v08i05.006 | **Received:** 04.04.2023 | **Accepted:** 10.05.2023 | **Published:** 16.05.2023

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Abstract

Artificial intelligence is defined as "the study and improvement of computer systems capable of performing tasks typically requiring cognitive abilities, such as image perception, speech recognition, decision making, and language translation." When a computer imitates analytical traits such as "learning and problem-solving," which humans normally connect with other human brains, the term "AI" is employed. A profusion of studies and papers on the function of AI in restorative dentistry have been published in recent years, with the majority of the efforts focusing on recognising and diagnosing dental disorders such as caries, gum disease, and tooth fractures. The major purpose of this study is to undertake a thorough review of prior research on the impact of artificial intelligence on restorative dentistry. The relevance of the theme tooth reconstruction was prioritised during the search. AI has achieved important improvements in a wide range of medical fields, most notably in dentistry for the diagnosis, localization, classification, estimation, and assessment of dental disease. This review only covers seven papers on the impact of AI on restorative dentistry. Artificial intelligence (AI) has advanced significantly as a powerful tool for computerised tooth repair during the previous two decades. More study is needed, however, to compare different types of AIs and assess their clinical usefulness in occlusal interface restoration.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, tooth structure, tooth restoration, restorative dentistry, dental prosthesis, prosthodontics.

INTRODUCTION

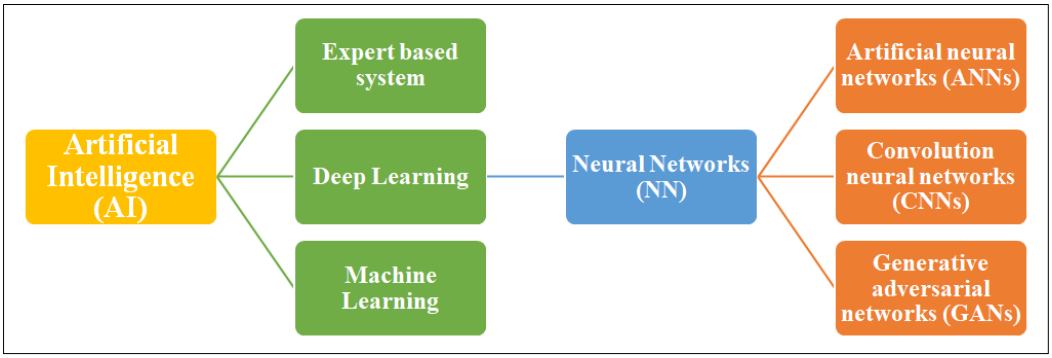
Scientists and researchers have always been fascinated by the brain, one of the most interesting organs of the human body. The world of science has never fully comprehended how to create a flawless model that corresponds to the human brain. For many years, scientists have been working tirelessly to improve "artificial intelligence" (AI). Artificial intelligence is described as "the study and improvement of computer systems capable of performing tasks usually involving cognitive abilities, such as perception of images, recognition of speech, making judgments, and language translation."

John McCarthy established the field of applied computer science known as artificial intelligence in 1956. AI research in computer science is the study of an intelligent medium, or any system that understands its surroundings and responds in a way that ensures its chances of success. The term "AI" is used when a computer imitates analytical characteristics such as "learning and problem-solving," which humans generally associate with other human brains.

AI is currently having an impact on our everyday routines as a result of various office and practises management software. Siri, Alexa, and other voice command devices are only a few instances of artificial intelligence-powered apps that have created sophisticated interactive user interfaces for any device, app language, or environment. In the sphere of health care, both virtual and mechanical AI (robotics) are beneficial. The math-based formulas for medication dosage, prognosis and medical diagnosis, scheduling appointments, medication interactions, electronic medical records, and imaging are the primary fields of the virtual type. The physical element includes rehabilitation, tele-presence, robotic assistance in surgery, and compatible robotic devices for senior care.

Most of the dental applications use controlled learning, with bulk samples, each with unique characteristics or features of patients, gender, age, number of cavities and previous dental treatment evaluation. Artificial neural networks (ANNs) are comparable to biological neuron systems in that they feature a high number of neural connections utilised in "learning" and are employed by its algorithm to grasp the link between qualities and the ground truth.

Numerous studies on AI applications in dentistry are being conducted or have already been implemented in areas like as diagnostics, decision-making, treatment planning, treatment outcome prediction, and disease prognosis. Several articles on dental AI have been published, but this review aims to outline the evolution of AI from its early stages to the present, describe AI classifications, summarise current advances in AI developments in dentistry, and discuss the connection between EBD (evidence based dentistry) and AI. The present constraints of the evolution of AI in dentistry are also explored.



Graphic Representation of Artificial Intelligence (AI)

In recent years, there has been a significant increase in the number of research investigating the application of artificial intelligence (AI) in restorative dentistry. Several research looked at the use of AI in aiding with caries and vertical tooth fracture detection, estimating restoration failures, and organising therapy.

Common oral disorders caused by dental illnesses, jaw pathologies, traumatic traumas, or hereditary abnormalities such as hypodontia and anodontia include loss of solid tooth substance and even full tooth loss. Missing tooth substances, if left untreated, tend to damage oral functions, systemic health, as well as persons' well-being and quality of life.

Dental prosthesis are a popular management strategy used in restorative dentistry to restore a patient's look and their oral functionality by replacing lost teeth and tooth components. Because patients may detect slight discrepancies at roughly 10 m, these procedures should take the occlusal layer of dental prosthesis seriously. For the greatest treatment outcomes, the resultant dental prosthesis should be as near to natural teeth as feasible in terms of occlusal morphology.

Restoring natural occlusal structure on a prosthetic tooth has always been a problem for dentists, and failure tends to increase failure and complication rates, as well as result in oral dysfunctions and poor oral health-related quality of life (OHRQoL). The use of data-driven technology in the treatment of dental disorders is considered as a 21st-century trend in oral healthcare, as the dentistry community aspires to become more personalised. The World Health Organisation (WHO) also states that dentists should use technology such as AI (artificial intelligence) to improve the quality, accessibility, and equal opportunity of oral and dental treatment.

In recent years, there has been a plethora of studies and publications on the role of AI in restorative dentistry, with the majority of the efforts focused on identifying and detecting dental problems such as caries, gum disease, and tooth fractures. According to the studies published, there have been few research on artificial intelligence (AI) in tooth repair, particularly AIs with computational learning capabilities. The purpose of this study was to provide a review of restorative dentistry and conventional dental practise in order to assist the use of AI technology in dentistry.

PURPOSE AND OBJECTIVES

The primary goal of this research is to conduct a comprehensive assessment of previous studies on the influence of artificial intelligence on restorative dentistry.

Specific Goals Include:

- Conducting an online literature study utilising several databases to assess the influence of AI on restorative dentistry.
- A look back at the history of artificial intelligence.
- Comprehensive understanding of the use of artificial intelligence in restorative dentistry.

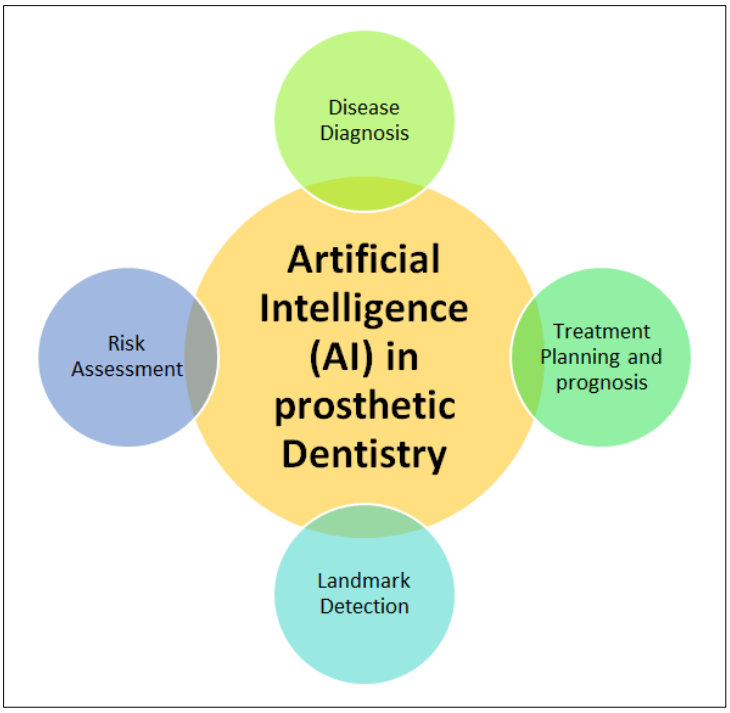
- Identifying the benefits and drawbacks of artificial intelligence applications.

METHODOLOGY

Artificial intelligence in tooth reconstruction studies were electronically searched across online databases, PubMed, Medline, and Google Scholar, without regard for publication time or any other filter. In searching, the relevance of the theme tooth reconstruction was prioritised. ("artificial intelligence (AI)" or "machine learning (ML)" or "deep learning (DL)") AND ("tooth structure" or "dental crowns" or "dental prosthetics" or "prosthodontics"). Original research data investigations were incorporated and addressed in this work. To avoid data overlap, review articles were eliminated. If a single research provided many articles at various time points, only the most current portion was included.

RESULT

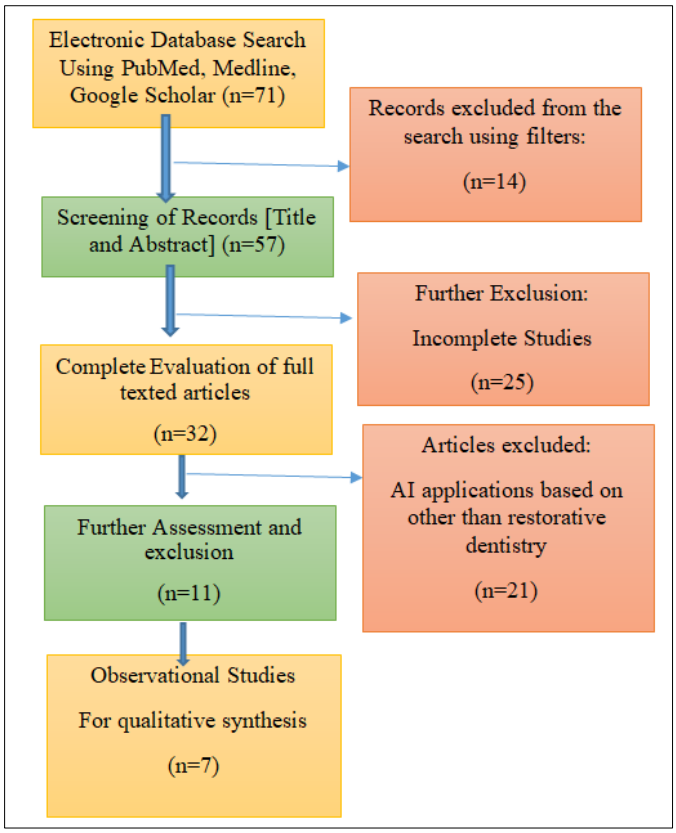
AI has made significant advances in a variety of medical areas, particularly in dentistry for diagnosis, localisation, categorization, estimate, and assessment of dental illness. Dental doctors produce precise diagnoses and deliver correct suggestions thanks to the recent rapid development of AI technology tailored for dental practitioners. The graph below depicts the areas of dentistry where artificial intelligence (AI) can be employed, followed by a full overview of AI applications in various professions.



Applications of Artificial Intelligence (AI) in restorative/prosthetic Dentistry

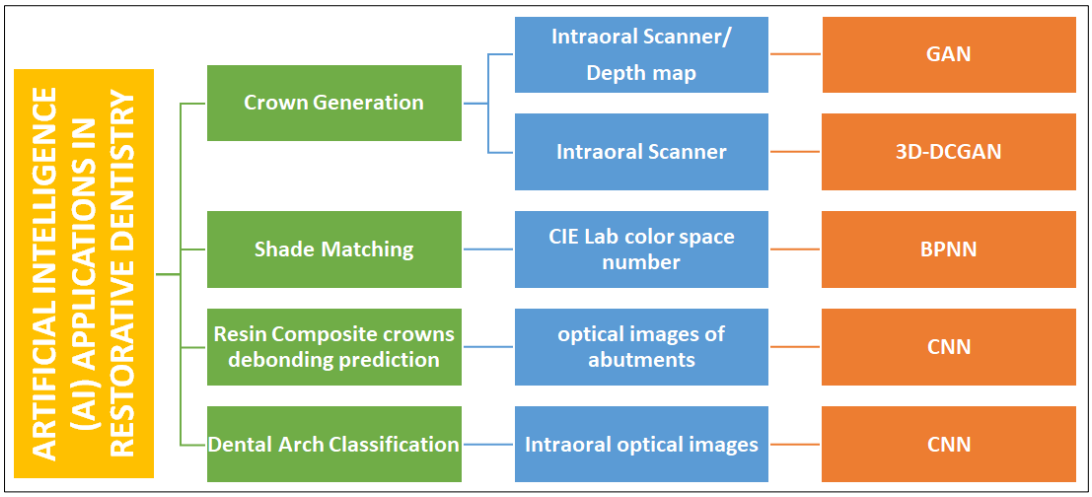
The flow chart below depicts the screening and identification of papers about the influence of AI on restorative dentistry. A total of 71 papers were found utilising electronic databases such as Pubmed, Medline, and Google scholar. Using the filters, 14 items were removed from the search after being reviewed. The papers were deleted because they just featured the title and abstract (approximately 25), and the remaining 32 articles were thoroughly reviewed by the senior investigator. If the study includes AI used for other dental procedures, another 21 papers were removed. 11 papers were evaluated further, and investigations were eliminated. This analysis includes just seven studies on the influence of AI on restorative dentistry.

To achieve many goals, academics have developed several AI classification techniques. AI is a catch-all phrase for all forms of non-human intelligence. AI is further divided into two types: weak AI and strong AI. A deep neural network can extract characteristics from input data without human involvement. It can instead learn those characteristics from massive datasets. Expert systems, on the other hand, require human interaction to learn. Neural networks (NNs) are biologically inspired networks that form the foundation of deep learning algorithms. There are several types of neural networks (NNs), the most notable of which are artificial neural networks (ANNs), convolution neural networks (CNNs), and generative adversarial networks (GANs).



Flow chart showing Screening and identification of the articles related to the impact of AI on restorative Dentistry

Authors Name	Year of Study	Name of Journal	Application of Artificial Intelligence (Ai)	Factor of Study	Type of Data Modality	Sample Size	Conclusion
Xu *et al.*, [9]	2018	IEEE Transactions on Visualization and Computer Graphics	Disease Segmentation	Preservation of tooth boundary	3D dental Images	1200	Using the 3D dental model, the label-free mesh simplification approach assisted in preserving the teeth boundary information.
Cui *et al.*, [10]	2020	Journal of Prosthetic Dentistry	Treatment planning and prognosis	Tooth Extraction Treatment	Electronic Health Records	4135	The model proved useful in predicting tooth extraction treatment, outperforming prosthodontists.
Javed *et al.*, [11]	2020	Computer Methods and Programming in Biomedicine	Treatment planning and prognosis	Occlusal caries lesions	Electronic Health Records	45	The model proved useful in occlusal dentinal caries lesions, and the study offers an iOS app for accurate caries prediction.
Lee *et al.*, [13]	2020	Medicine (Baltimore)	Disease Diagnosis	Dental Implants	Panaromic and periapical radiographs	10770	The model proved useful in identifying and classifying dental implants that performed similarly to periodontists.
Abdallah Aslan *et al.*, [14]	2020	Oral Surgery, Oral medicine, Oral Pathology, Oral radiology	Disease Detection	Dental Restorations	Panaromic radiographs	83	The model has the capacity to identify and categorise dental restorations in order to improve the health of patients.
Takahashi *et al.*, [15]	2021	IEEE Transactions on Visualization and Computer Graphics	Disease Diagnosis	Partially edentulous arches	Oral Photographs	1184	The approach proved useful in classifying dental arches and might be useful in creating detachable partial dentures.
Lee *et al.*, [16]	2022	Diagnostics	Treatment Planning	Tooth prognosis	Electronic records	94	The model proved useful in assessing dental prognosis in order to plan optimal therapy.



Graphic Representation of Artificial Intelligence (AI) in Restorative Dentistry

DISCUSSION

Historically, dental prostheses were manufactured by dental technicians, therefore occlusal reconstruction accuracy was prone to human error and was dependent on the expertise and talents of dental professionals. Furthermore, employing a semi-adjustable articulating device to replicate a person's jaw movement and design the occlusal structure of dental prosthesis is insufficient for replicating real occlusal anatomy. While completely adjustable articulators allow for more accurate modelling of jaw motions, they are costly, require lengthy training, and need sophisticated understanding.

Alhouri *et al.*, offered a mathematical study of crown shape in relation to the parallel tooth in the same arch in 2004 [17].The goal was to investigate the oversized or over-contour of dental restorations. When only limited information on the physical characteristics of a specific tooth was available, computational models of tooth structure were developed for three-dimensional reconstruction of a tooth. Similarly, a paradigm for tooth morphology in planetology and anthropological research was provided using the quasi-conformal theory.

With the evolution of bigeneric tooth models and programmable AI in recent years, such designs have been enabled by the development of computer-aided design-computer-aided manufacturing (CAD-CAM) technology. According to Chen *et al.*, CAD-CAM systems were still rated superior than AI equivalents in terms of shape and fracture behaviours by 2022 [18]. Blanz *et al.*, presented an algorithm that used statistical methodologies to reconstruct a 3D model based on perceived dimensions of 2D images, which could potentially be used to restore three-dimensional surfaces of teeth utilising inlay designs [19]. Steinbrecher *et al.*, suggested automating the fabrication of inlays and onlays using Laplacian Surface Editing technology [20]. To preserve the system's residual tooth surface, mesh patterns from tooth collections were applied. However, significant manual adjustments were necessary to produce a functional prosthesis design for CAD-CAM fabrication.

The Biogeneric dental design was also a mathematical reconstruction of a lost tooth surface based on the remaining tooth material. Mehl *et al.*, calculated the average shape of maxillary first molar crowns [21]. These mathematical computations were used to create biogeneric tooth models for CAD-CAM concepts, applications for VR in dentistry education, and parametric estimates of tooth morphology. Richter *et al.*, created inlays and onlays for the occlusal surfaces of numerous mandibular molars using biogeneric tooth models [22]. They showed that with an average deviation, reconstruction using biogeneric dental models was achievable.

Another study found that the resultant prosthesis could recover better morphology in less time. In comparison to standard CAD-CAM-designed prostheses, they required significantly less occlusal adjustment time. Following that, two investigations evaluated the occlusal structure of crowns created by computer programmes based on the biogeneric tooth model to those created by human dental workers. They discovered that CAD-CAM reconstructions were more similar to the natural teeth than human-designed analogues. However, Kwon *et al.*, claimed that the biogeneric dental designs were not as precise as described when compared to the morphology of genuinely healthy teeth, owing to the limited repeatability of the CAD-CAM occlusal design [23].

A variety of AI (artificial intelligence) have been utilised to aid in the artwork of tooth repair during the last 20 years, albeit they cannot yet replace the duties of dentists or dental professionals [24]. Several limitations have been identified in the research that has been collected. One of these constraints is that most AI initiatives are built on mathematical frameworks that do

not learn from experience. Furthermore, the algorithms employ supervised learning, which only learns the precise patterns determined by the dentists and so cannot uncover new patterns for improved learning, like unsupervised learning does. More research into Deep Learning in tooth reconstruction, as well as observations of different learning algorithms, may be required [25].

Data dimensions appear to be another possible area for advancement in AI research. In the majority of the AI research gathered, only two-dimensional information is used to train the artificial intelligence (AI) system for a three- dimensional tooth restoration [26]. The use of a three-dimensional dental models for learning is preferred since they give more information and are more precise, eliminating the angular distortion that occurs when recording two-dimensional photos. Further research on the use of a three-dimensional data in tooth restoration may be required to determine whether the artificial intelligence (AI) system's quality and accuracy have increased.

Another essential element in the field of machine learning is the collecting of suitable samples. Although the educational databases are homogeneous, allowing for few-shot learning (training with a small sample size), a suitable Deep Learning model using 3D data may take up to 1000 sets of training data to attain minimal desired precision. Finally, none of the Deep Learning research included clinical trials, therefore there are no assessments of their clinical performance, particularly in terms of dynamic occlusion, aesthetics, patient acceptability, and so on. As a result, further research would be required before a larger deployment of Machine Learning models in restorative dentistry.

CONCLUSION

Artificial intelligence (AI) models have the potential to be an effective tool for diagnosing caries and vertical tooth fracture, identifying the preparation of teeth margin, and forecasting restorative failure. However, the dental applications of AI models are still in the early stages of research. More research is needed to evaluate the clinical outcomes for artificial intelligence (AI) models in dental restoration. Over the last two decades, artificial intelligence (AI) has made great development as a strong tool for computerised tooth restoration. However, more research is needed to compare different types of AIs and evaluate their clinical efficacy in the repair of occlusal interfaces.

Ethical Considerations: Adherence to ethical principles.

Ethical Permission

Because this study includes a comprehensive assessment of the impact of Artificial intelligence on restorative dentistry, no ethical approval is required.

CONFLICT OF INTEREST

The authors have no business relationships that might pose or create a conflict of interest with the material contained in this communication. This work was not sponsored by any intramural or extramural funding.

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