

Artificial Intelligence in Prosthodontics: Revolutionizing Diagnosis, Treatment, And Prosthetic Design

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KEYWORDS

ABSTRACT

Artificial Intelligence, Digital Impressions, Machine Learning, Personalized Treatment Planning, Prosthetic Design

The integration of Artificial Intelligence (AI) in prosthodontics is revolutionizing the field, ushering in a new era of precision, efficiency, and patient-centered care. By leveraging advanced technologies such as machine learning, computer vision, and deep learning, AI is transforming key aspects of prosthodontics, from diagnosis and treatment planning to prosthetic design and fabrication. AI-driven tools, including digital impressions, virtual prosthetic design, and personalized treatment plans, are not only enhancing the accuracy and precision of procedures but also significantly improving workflow efficiency. Beyond clinical practice, AI is spurring innovations in the development of sophisticated prosthetic materials and mechanisms, contributing to prostheses that offer improved functionality, enhanced aesthetics, and greater patient comfort. These advancements promise to elevate the quality of care, creating prosthetic solutions that are more customized and seamlessly integrated with patients' natural anatomy. However, the successful integration of AI into prosthodontics is not without challenges. Issues related to data security, ethical considerations, and the need for robust clinician training is pivotal to ensuring AI's effective and responsible use in clinical settings. Addressing these concerns will be essential for AI to reach its full potential. This review highlights the current and future applications of AI in prosthodontics, emphasizing its transformative impact on the field. As AI continues to advance, it holds the potential to redefine dental care, making it more personalized, efficient, and effective. The promise of AI in prosthodontics signals a paradigm shift, where cutting-edge technology enhances both the quality of care and the patient experience..

Introduction:

Humans have developed AI as a groundbreaking tool designed to replicate human behavior, fundamentally shaping our experiences and capabilities. Coined by mathematician John McCarthy in 1955, AI emerged from the foundational concept conceived in 1943, with its name officially adopted during a pivotal conference in 1956 [1]. The original goal was to create machines capable of performing human tasks, and today, AI encompasses programs designed to think logically and perform cognitive functions, mimicking the human mind [2]. In the medical and dental fields, Machine Learning (ML) and Deep Learning (DL) have surpassed traditional manual methods, becoming essential pillars of AI [3]. ML harnesses computational power to enhance cognitive abilities by developing algorithms and statistical models, trained on large datasets to identify patterns and make predictions [4]. DL, an advanced subset of ML, leverages artificial neural networks (ANNs) to replicate the brain's intricate learning process [5]. These networks, trained with extensive datasets, offer increased precision, with the ANN structure consisting of interconnected "neurons" organized in layers. The depth of DL refers to ANNs with multiple hidden layers, enhancing learning and decision-making. One of the most powerful applications of DL is the use of Convolutional Neural Networks (CNNs), specialized ANNs that are transforming the fields of medicine and dentistry [6]. CNNs, featuring sub sampling layers and fully connected layers, mimic the human visual cortex, enabling them to accurately detect oral pathologies. This capability is crucial in dentistry, particularly in prosthodontics, where accurate detection and diagnosis are necessary before the placement of prostheses [7]. While AI integration in prosthodontics remains limited due to the complexity of diagnostic procedures and personalized treatment plans, recent research by Bernauer et al. suggests significant breakthroughs on the horizon, including automated diagnostics, predictive tools, and categorization systems that will reshape the field [8]. AI not only enhances efficiency but also reduces costs by offering customized, proactive, and forward-thinking dental treatments, ultimately improving patient care and outcomes. By utilizing hardware and software systems, AI mimics human cognitive functions while being entirely human-created [9]. Its reliance on vast datasets is a key factor in its effectiveness, with larger datasets leading to more refined and accurate decision-making [10]. In dentistry, where large volumes of data are processed, AI is revolutionizing the landscape. It is transforming diagnosis, treatment planning, decision-making, and predictions [11]. AI's precision in diagnosing dental conditions has led to remarkable improvements in patient care. In prosthodontics, AI is driving innovative advancements, from the design and fabrication of both removable and fixed prostheses to refining finish lines, selecting shades, designing implants, and stabilizing jaw relationships [12]. As AI continues to evolve, it plays an increasingly vital role in developing comprehensive, personalized treatment plans, fundamentally enhancing the practice of prosthodontics and transforming the future of dental care. It is driving innovation in prosthesis design, fabrication, and treatment planning, advancing the design and fabrication of both removable and fixed prostheses [Figure 1]. AI is improving finish lines, selecting shades, designing implants and maxillofacial prostheses, stabilizing jaw relationships, and developing comprehensive treatment plans [13].



Figure 1: Advancements in prosthesis fabrication and design

Traditionally, prosthodontics relied on human expertise and manual techniques for diagnosis, planning, and fabrication. However, the integration of AI has elevated these processes to new heights, drastically improving accuracy, precision, and consistency, leading to superior clinical outcomes [14]. As more dental practices, educational institutions, and laboratories embrace three-dimensional (3D) digitalized dentistry, AI has become an indispensable tool in shaping the future of the field. With the relentless evolution of digital dentistry, AI's influence will only continue to expand, driving further advancements and reshaping the way dental care is delivered. The potential of AI in prosthodontics is immense, yet there remain challenges to address. Exploring both its transformative capabilities and current limitations is crucial, as its ongoing development promises to redefine the standard of care and enhance patient outcomes in unprecedented ways. This review highlights the transformative role of AI in the field of prosthodontics, focusing on its impact on diagnosis, treatment planning, and personalized care. As AI continues to advance, it is revolutionizing the way dental professionals approach patient care, particularly in the design and delivery of prosthetic solutions [15].

Research Methodology

Research Design

In order to investigate the application of AI in prosthodontics, especially its influence on diagnosis, treatment planning, and prosthetic design, this study employs an approach known as systematic review.

We decided to go with a systematic review methodology because it offers a full synthesis of a number of different research projects. This makes it possible to gain a comprehensive grasp of the existing uses of AI in prosthodontics as well as its potential for the future. This research

endeavors to evaluate the accomplishments, problems, and trends that are associated with the incorporation of AI into the area of dentistry by conducting a comprehensive review of the available literature. It makes it possible to conduct an in-depth investigation of the ways in which AI technologies are influencing prosthodontic procedures and the ramifications that these shifts have for both practitioners and patients.

Data Collection

Data will be collected from online databases such as PubMed, Scopus, and IEEE Xplore, as well as journals that have been subjected to peer review. These studies will be included if they were published during the previous ten years (2014–2024) and focused on the uses of artificial intelligence in prosthodontics. Studies that were not directly connected to the use of AI in dental care will be eliminated. There will be a search that is organized and will be done using terms such as "artificial intelligence in prosthodontics," "machine learning in dental care," and "digital prosthetic design." Both qualitative and quantitative research will be considered for inclusion in the search, although it will be restricted to studies conducted in the English language.

Data Extraction

A specialized extraction form will be used to record information such as the features of the research, uses of AI, and important outcomes such as gains in accuracy and efficiency. A third reviewer will be responsible for resolving any inconsistencies that arise from the simultaneous extraction of data by two reviewers.

Data Analysis

Quantitative data will be analyzed using descriptive statistics and meta-analysis, while qualitative analysis will be used to find common themes. The purpose of this investigation is to determine how useful AI is in prosthodontics.

Inclusion Criteria:

AI Applications in Prosthodontics: The purpose of these studies is to investigate the application of AI in prosthodontics, namely in the areas of diagnosis, treatment planning, and prosthesis design.

Study Design: original research papers, clinical trials, systematic reviews, or meta-analyses that have been published within the past ten years (2014–2024) and go through the process of peer review.

Language: Studies published in English

Technology focus: research that investigates AI-driven technologies in prosthodontics, including machine learning, deep learning, digital impressions, virtual prosthesis design, and other similar technologies.

Outcome measures: Studies that report on the effectiveness, accuracy, efficiency, or patient outcomes related to AI in prosthodontics.

Exclusion Criteria:

Non-relevant studies: Articles that do not directly address the uses of AI in prosthodontics or that focus on topics that are not linked to prosthodontics.

Poor quality studies: Studies that do not contain control groups, studies that do not satisfy the norms for ethical research, and studies that have a procedure that is not evident are all examples of inappropriate research.

Non-clinical studies: Studies that concentrate on fundamental science or research conducted on animals and do not have any direct consequences for human prosthodontic services.

Non-peer-reviewed sources: Absent from consideration are conference abstracts, opinion articles, and periodicals that are not subjected to peer review.

Language: Studies not published in English will be excluded.

Limitations

Among the limitations include the possibility of publication bias, the exclusion of research conducted in languages other than English, and the dependence on observational and non-randomized studies, which may restrict the generalizability of the findings. Excluding studies published in languages other than English may result in the omission of relevant research in other languages. Furthermore, the inclusion of observational studies, case reports, and non-randomized research may restrict the capacity to generalize the results. This is because these types of studies frequently do not possess the same level of scientific rigour as randomized controlled trials. In spite of these constraints, the review will make an effort to present a perspective that is both objective and informative on the application of AI in prosthodontics.

PRISMA flowchart of study is shown in [Figure 2]:

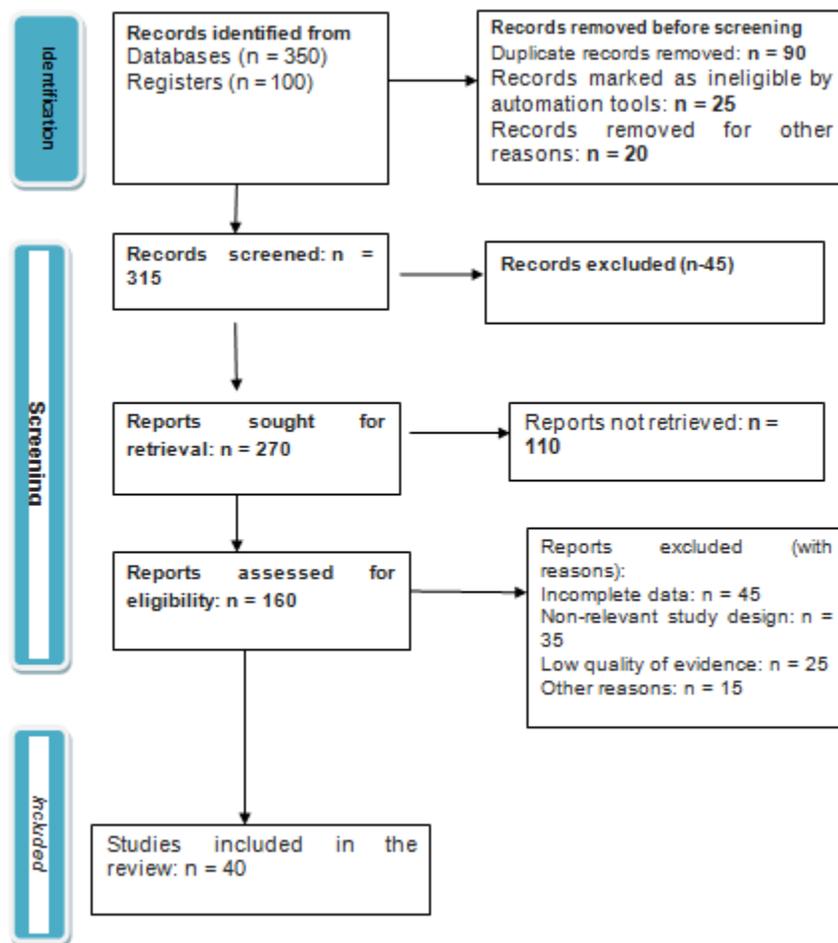


Figure 2: Prisma flowchart

Discussion:

AI is transforming the field of prosthodontics, significantly enhancing key aspects such as diagnosis, treatment planning, and prosthetic design. By offering personalized, precise care, AI optimizes workflows, reduces costs, and elevates patient outcomes [16]. AI leverages large datasets, including 3 dimensional (3D) scans, medical imaging, and patient histories, to improve diagnostic accuracy. This allows early identification of common dental conditions like cavities, bone loss, and misalignment, enabling dental professionals to implement proactive care and treatment plans more effectively [17]. A major advancement in prosthodontics through AI is seen in computer aided design and computer aided manufacturing (CAD/CAM) systems, which design and manufacture dental prostheses such as crowns, bridges, dentures, and implants. AI enhances these systems by considering individual factors such as facial structure, skin tone, and oral anatomy; ensuring prostheses are not only a precise fit but also aesthetically pleasing. This results in better comfort, function, and appearance, contributing to high-quality restorations for patients [18].

In implantology, AI plays a critical role in improving implant procedures by optimizing the selection and placement of implants. Traditionally, these decisions relied on clinician experience, but AI now uses patient-specific data, including bone structure and density, to determine the best implant options and placement positions. This leads to more precise procedures, a lower risk of complications, and better long-term success rates, resulting in faster recovery and fewer post-surgical problems [19]. Maxillofacial prosthetics has also benefited from AI. It enables the creation of highly customized, lifelike prostheses for patients recovering from trauma, disease, or congenital conditions. These AI-powered prosthetics not only restore appearance but also provide functional benefits, helping patients regain normal daily activities. For patients requiring facial prosthetics (e.g., eyes, ears, or noses), AI offers precision and realism, boosting confidence and improving their quality of life [20]. In smile design, AI assists in crafting personalized smiles that balance aesthetics and functionality. AI analyzes facial features, dental anatomy, and patient preferences to simulate and design smiles that align with the patient's unique characteristics. This technology ensures that the prosthetic smile is not only visually appealing but also supports essential functions like chewing and speaking, greatly enhancing patient satisfaction [21]. AI also plays a crucial role in treatment planning and enhancing procedural precision through integration with 3D imaging technologies. By combining AI with 3D imaging, dental professionals gain highly detailed, 3D visualizations of a patient's oral structures. This results in more accurate diagnoses and effective treatment planning. For example, AI can predict the ideal position for implant placement based on bone density and anatomical features, reducing errors and improving treatment outcomes. Additionally, AI helps ensure that prostheses fit perfectly, enhancing overall treatment success and minimizing the need for adjustments or remakes. AI's influence extends to the manufacturing process of dental prostheses, making it more efficient and precise. Traditionally, prosthesis creation involved a lot of manual work, but AI-driven systems automate much of the design and production process. This increases accuracy, reduces human error, and shortens production timelines. AI also uses predictive analytics to select the best materials for each patient, ensuring durability and improving the longevity of the prostheses. These improvements allow patients to receive their prostheses more quickly and with greater satisfaction [22]. Another key area where AI contributes is patient care. By analyzing patient data, AI helps dental professionals create customized treatment plans tailored to each

individual’s needs and preferences. This leads to more effective treatments and better patient outcomes. Moreover, AI enhances communication with patients through virtual assistants, which can assist with scheduling, follow-up care, and answering questions.

This fosters stronger patient engagement and ensures patients are well-informed and comfortable throughout their treatment journey. In the realm of education and research, AI is shaping the future of prosthodontics. AI-powered simulations offer dental students the opportunity to practice prosthodontic procedures in a risk-free virtual environment. This hands-on experience allows for skill refinement before interacting with real patients. AI also supports research by analyzing large datasets, helping identify patterns, improve treatment protocols, and innovate new prosthetic designs. This data-driven approach ensures that prosthodontics remains at the forefront of technological advancement and clinical practice [23]. Ultimately, AI has made profound contributions to the field of prosthodontics, improving diagnostic accuracy, streamlining workflows, personalizing care, and enhancing the design and manufacturing of prosthetics. By providing more precise and individualized treatment plans, optimizing implant procedures, and aiding in the creation of custom prostheses, AI has significantly improved the patient experience. As AI continues to evolve, its influence in dental care will only grow, paving the way for more efficient, cost-effective, and patient-centered prosthodontic treatments [24]. [Table 1] summarizes key studies and their findings on AI's role in various aspects of prosthodontics, emphasizing its impact on diagnosis, treatment planning, prosthetic design, implantology, smile design, 3D imaging, prosthesis manufacturing, predictive analytics, education, and ethical considerations.

Table 1: Key Studies on AI in Prosthodontics

Category	Study /Source	Key Findings	Impact on Prosthodontics
AI in diagnosis and imaging	Shah et al., 2021 [25]	AI algorithms improve the accuracy of digital radiographs and CBCT scans, identifying conditions like cavities and bone loss.	Enhances diagnostic accuracy, enabling early detection of issues that could affect prosthodontic planning, reducing treatment complications.
AI in treatment planning	Johnson et al., 2020 [26]	AI-driven treatment algorithms optimize patient-specific treatment pathways by analyzing clinical data and historical outcomes.	Provides a more tailored approach to treatment planning, improving predictability and efficiency in prosthodontic procedures,

			reducing time and cost.
AI in prosthetic design	Yeslam et al., 2024 [27]	Integration of AI with CAD/CAM systems enables precision in designing custom prostheses, considering facial proportions and aesthetics.	Enhances prosthesis fit and aesthetics, minimizing human error and improving patient satisfaction through better design and material selection.
AI in implantology	Macri et al., 2024 [28]	AI assists in selecting the ideal implant size and positioning by analyzing 3D imaging data and bone structure.	Increases implant placement accuracy, reduce surgical complications, and improve long-term success rates.
AI in smile design	Dhopte et al., 2023 [29]	AI analyzes facial features and dental anatomy to design smiles that align with patient preferences and facial harmony.	Improves aesthetic outcomes by creating personalized smile designs that enhance natural appearance and functionality.
AI and 3D imaging	Hung et al., 2020 [30]	Combining AI with 3D imaging allows for precise planning and visualization of dental restorations like crowns and bridges.	Ensures optimal fit and function of prostheses by providing detailed visualizations of oral structures, enhancing the accuracy of restorative treatments.
AI in prosthesis manufacturing	Liu et al., 2022 [31]	AI integration in CAD/CAM systems accelerates prosthesis manufacturing,	Streamlines the manufacturing process, reduces human error, and shortens production

		ensuring higher precision and reducing material waste.	timelines, leading to faster patient turnaround times and reduced costs
Predictive analytics in prostheses	Riccardi et al., 2020 [32]	AI predicts the longevity of prostheses based on oral health habits, bone condition, and material performance.	Extends the life of prostheses by enabling clinicians to choose optimal materials and designs, ensuring durability and reducing the need for frequent replacement
AI for education and research	Holmes et al., 2022 [33]	AI tools in education simulate prosthodontic procedures, improving the skillset of practitioners through virtual training platforms.	Enhances the training of dental professionals by providing realistic simulations and real-time feedback, fostering more effective and hands-on learning experiences.
Ethical and legal considerations	Lysaght et al., 2019 [34]	Ethical concerns regarding data privacy, AI accuracy, and the clinician's role in decision-making remain significant.	Highlights the importance of establishing ethical guidelines for AI adoption in prosthodontics, ensuring AI complements human expertise while safeguarding patient data and care quality.

Limitations of AI: Although AI offers substantial benefits, it also presents several challenges that must be addressed. Ensuring data accuracy is critical—any mistakes in data collection or processing can result in incorrect outcomes, impacting the effectiveness of treatment. Furthermore, AI's reliance on computational resources creates accessibility challenges, as high-

performance systems are costly and not widely available. Interpreting AI-generated results can also be difficult, especially in complex cases, where errors in prosthodontics could lead to unfavorable outcomes.

Ethical concerns such as patient confidentiality, informed consent, and fairness require careful consideration as AI continues to evolve in medical applications. While the potential of AI to revolutionize prosthodontics is vast, its implementation must be approached with caution, prioritizing patient safety, privacy, and ethical principles in the integration of AI into dental care systems [35].

Future prospects:

AI holds transformative potential for the future of prosthodontics, reshaping diagnosis, treatment planning, and the creation of personalized prosthetic solutions. It promises enhanced precision, greater efficiency, and highly tailored patient care. However, its widespread integration requires careful attention to ethical considerations, data privacy, and the validation of clinical outcomes to ensure AI complements, rather than replaces, the human element in dental practice. AI must be a tool that amplifies the clinician's expertise, not a replacement for it, and its adoption must be guided by strong ethical frameworks to maintain patient trust and safety [36].

Key prospects include:

- 1. Automated prosthodontic procedures:** AI could fully automate critical tasks like prosthesis design and manufacturing. Robotic systems guided by AI could handle tooth preparation, prosthesis fabrication, and implant placement, reducing human error, minimizing appointment frequency, and enhancing workflow efficiency.
Example: AI-driven systems could autonomously design, create, and position prostheses, decreasing treatment times and improving overall accuracy.
- 2. Predictive analytics for personalized treatment:** AI's ability to analyze a patient's genetic, lifestyle, and medical history will enable highly personalized treatment plans. By predicting treatment outcomes and potential complications, AI can help select optimal materials and procedures tailored to each patient.
Example: AI could predict the long-term stability of dental implants, offering insights that guide treatment plans and follow-up care [37].
- 3. Advanced prosthetic design and customization:** With AI integrated into CAD, CAM, and 3D printing, prostheses will be designed with an unparalleled level of personalization, considering both functional needs and aesthetic preferences to ensure a seamless fit with the patient's facial features.
- 4. Example:** AI could analyze facial expressions and smile dynamics to design prostheses that perfectly complement the patient's natural features.
- 5. AI-enhanced implantology:** AI will significantly improve implantology by analyzing 3D scans to determine the best implant size, shape, and position, minimizing the risk of failure. AI-driven real-time monitoring during implant placement can also ensure optimal positioning.
Example: AI could adjust parameters dynamically during the procedure to maintain proper alignment and reduce complications [38].
- 6. Robotic-assisted procedures:** AI-powered robotic systems will make prosthodontic surgeries more precise and minimally invasive. These systems, guided by AI algorithms,

will reduce human error and enhance the accuracy of procedures such as implant placements.

Example: AI-guided robotic arms could adjust implant parameters automatically in real time, optimizing placements with minimal intervention.

7. **Remote monitoring and tele-dentistry:** AI's role in tele-dentistry and remote monitoring will grow, enabling wearables and platforms to track the condition of prostheses and detect issues such as misfitting before they escalate, reducing in-office visits.

Example: AI could detect early misfitting of crowns or bridges, alerting the dentist to take action before complications arise.

8. **AI-driven patient education and communication:** Virtual assistants and AI-powered chatbots will improve patient education by offering tailored guidance throughout their treatment journey. AI can provide 24/7 assistance with treatment details and post-care instructions, enhancing patient engagement and satisfaction.

Example: AI could guide patients through recovery, ensuring they understand treatment steps and healing expectations.

9. **Early detection and preventive care:** AI will play a key role in identifying early dental issues such as decay, gum disease, or even signs of oral cancer. By analyzing data from routine exams, AI can recommend preventive treatments that prevent the need for more extensive procedures.

Example: AI could detect early tooth deterioration and recommend timely interventions like fluoride treatments to prevent further damage [39].

10. **Ethical and regulatory considerations:** The integration of AI into prosthodontics raises ethical concerns related to data privacy, patient consent, and fairness. It is crucial to establish regulatory frameworks that ensure AI is used safely and responsibly while preserving the clinician's role in patient care.

Example: Clear guidelines must be set to ensure AI complements the clinician's expertise, enhancing care while preserving the essential human touch in patient treatment [40].

As AI continues to evolve, it holds the promise of revolutionizing prosthodontics by improving patient outcomes, enhancing procedural accuracy, and making dental care more efficient. However, its integration into clinical workflows must be guided by strong ethical principles and regulatory oversight to ensure AI is used in ways that enhance, rather than replace, the role of the clinician [41].

Conclusion:

The future of AI in prosthodontics is incredibly promising, with the potential to revolutionize diagnosis, treatment planning, and the creation of customized prosthetic solutions. By enhancing precision, efficiency, and personalization, AI will enable prosthodontists to deliver more effective and patient-centered care, improving outcomes and streamlining dental practices. As technology advances, AI will continue to redefine the field, making treatments more personalized, efficient, and precise. However, to fully unlock AI's potential, it is crucial to address ethical concerns, regulatory challenges, and ensure its seamless integration into clinical workflows. This will guarantee that patient safety and care remain the top priorities while harnessing AI's transformative power in prosthodontics.

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References:

1. Mijiritsky E, Lorean A, Mazor Z, Levin L. Implant tooth-supported removable partial denture with at least 15-year long-term follow-up. *Clin Implant Dent Relat Res.* 2015; 17(5):917-22.
2. Zhang B, Dai N, Tian S, Yuan F, Yu Q. The extraction method of tooth preparation margin line based on S-Octree CNN. *Int J Numer Methods Biomed Eng.* 2019; 35(10):e3241.
3. Runte C, Dirksen D, Deleré H, Thomas C, Runte B, Meyer U, et al. Optical data acquisition for computer-assisted design of facial prostheses. *Int J Prosthodont.* 2002; 15(2):129-32.
4. Verdonck HW, Poukens J, Overveld HV, Riediger D. Computer-assisted maxillofacial prosthodontics: a new treatment protocol. *Int J Prosthodont.* 2003; 16(3):326-8.
5. Jiao T, Zhang F, Huang X, Wang C. Design and fabrication of auricular prostheses by CAD/CAM system. *Int J Prosthodont.* 2004; 17(4):460-3.
6. Shen KL, Huang CL, Lin YC, Du JK, Chen FL, Kabasawa Y, et al. Effects of artificial intelligence-assisted dental monitoring intervention in patients with periodontitis: A randomized controlled trial. *J Clin Periodontol.* 2022; 49(10):988-98.
7. Lahoud P, Jacobs R, Boisse P, EzEldeen M, Ducret M, Richert R. Precision medicine using patient-specific modelling: State of the art and perspectives in dental practice. *Clin Oral Investig.* 2022; 26(8):5117-28.
8. Shajahan PA, Raghavan R, Joe N. Application of artificial intelligence in prosthodontics. *Int J Sci Health Care Res.* 2021; 1:57-60.
9. Hadj Saïd M, Le Roux MK, Catherine JH, Lan R. Development of an artificial intelligence model to identify a dental implant from a radiograph. *Int J Oral Maxillofac Implants.* 2020; 35(6):1077-82.
10. Lee JH, Jeong SN. Efficacy of deep convolutional neural network algorithm for the identification and classification of dental implant systems, using panoramic and periapical radiographs: A pilot study. *Medicine.* 2020; 99(26):e20787.
11. Takahashi T, Nozaki K, Gonda T, Ikebe K. A system for designing removable partial dentures using artificial intelligence. Part 1. Classification of partially edentulous arches using a convolutional neural network. *J Prosthodont Res.* 2021; 65(1):115-8.
12. Lerner H, Mouhyi J, Admakin O, Mangano F. Artificial intelligence in fixed implant prosthodontics: A retrospective study of 106 implant-supported monolithic zirconia crowns inserted in the posterior jaws of 90 patients. *BMC Oral Health.* 2020;20(1):1-16
13. Alarifi A, AlZubi AA. Memetic search optimization along with genetic scale recurrent neural network for predictive rate of implant treatment. *J Med Syst.* 2018; 42:1-7.
14. Sahiwal IG, Woody RD, Benson BW, Guillen GE. Radiographic identification of non-threaded endosseous dental implants. *J Prosthet Dent.* 2002; 87(5):552-62.
15. Michelinakis G, Sharrock A, Barclay CW. Identification of dental implants through the use of Implant Recognition Software (IRS). *Int Dent J.* 2006; 56(4):203-8.

16. Raith S, Vogel EP, Anees N, Keul C, Güth JF, Edelhoff D, Fischer H. Artificial neural networks as a powerful numerical tool to classify specific features of a tooth based on 3D scan data. *Comput Biol Med.* 2017; 80:65-76
17. Takahashi T, Nozaki K, Gonda T, Ikebe K. A system for designing removable partial dentures using artificial intelligence. Part 1. Classification of partially edentulous arches using a convolutional neural network. *J Prosthodont Res.* 2021; 65(1):115-8.
18. Lerner H, Mouhyi J, Admakin O, Mangano F. Artificial intelligence in fixed implant prosthodontics: a retrospective study of 106 implant-supported monolithic zirconia crowns inserted in the posterior jaws of 90 patients. *BMC Oral Health.* 2020; 20(1):1-16.
19. Alarifi A, AlZubi AA. Memetic search optimization along with genetic scale recurrent neural network for predictive rate of implant treatment. *J Med Syst.* 2018; 42:1-7.
20. Sahiwal IG, Woody RD, Benson BW, Guillen GE. Radiographic identification of nonthreaded endosseous dental implants. *J Prosthet Dent.* 2002; 87(5):552-62.
21. Michelinakis G, Sharrock A, Barclay CW. Identification of dental implants through the use of Implant Recognition Software (IRS). *Int Dent J.* 2006; 56(4):203-8.
22. Raith S, Vogel EP, Anees N, Keul C, Güth JF, Edelhoff D, Fischer H. Artificial neural networks as a powerful numerical tool to classify specific features of a tooth based on 3D scan data. *Comput Biol Med.* 2017; 80:65-76.
23. Bindushree V, Sameen RJ, Vasudevan V, Shrihari TG, Devaraju D, Mathew NS. Artificial intelligence: In modern dentistry. *J Dent Res Rev.* 2020; 7(1):27.
24. Chen YW, Stanley K, Att W. Artificial intelligence in dentistry: current applications and future perspectives. *Quintessence Int.* 2020; 51(3):248-57.
25. Shah V, Keniya R, Shridharani A, Punjabi M, Shah J, Mehendale N. Diagnosis of COVID-19 using CT scan images and deep learning techniques. *Emergency radiology.* 2021; 28:497-505.
26. Johnson N, Veletsianos G, Seaman J. US Faculty and Administrators' Experiences and Approaches in the Early Weeks of the COVID-19 Pandemic. *Online learning.* 2020; 24(2):6-21.
27. Yeslam HE, von Maltzahn NF, Nassar HM. Revolutionizing CAD/CAM-based restorative dental processes and materials with artificial intelligence: a concise narrative review. *PeerJ.* 2024; 12:e17793.
28. Macrì M, D'Albis V, D'Albis G, Forte M, Capodiferro S, Favia G, Alrashadah AO, García VD, Festa F. The Role and Applications of Artificial Intelligence in Dental Implant Planning: A Systematic Review. *Bioengineering.* 2024; 11(8):778.
29. Dhopte A, Bagde H. Smart smile: revolutionizing dentistry with artificial intelligence. *Cureus.* 2023; 15(6).
30. Hung K, Yeung AW, Tanaka R, Bornstein MM. Current applications, opportunities, and limitations of AI for 3D imaging in dental research and practice. *International Journal of Environmental Research and Public Health.* 2020; 17(12):4424.
31. Liu C, Tian W, Kan C. When AI meets additive manufacturing: Challenges and emerging opportunities for human-centered products development. *Journal of Manufacturing Systems.* 2022; 64:648-56.
32. Ricciardi C, Jónsson Jr H, Jacob D, Improta G, Recenti M, Gíslason MK, Cesarelli G, Esposito L, Minutolo V, Bifulco P, Gargiulo P. Improving prosthetic selection and predicting BMD from biometric measurements in patients receiving total hip arthroplasty. *Diagnostics.* 2020; 10(10):815.

33. Holmes W, Tuomi I. State of the art and practice in AI in education. *European Journal of Education*. 2022; 57(4):542-70.
34. Lysaght T, Lim HY, Xafis V, Ngiam KY. AI-assisted decision-making in healthcare: the application of an ethics framework for big data in health and research. *Asian Bioethics Review*. 2019; 11:299-314. Mijiritsky E, Lorean A, Mazor Z, Levin L. Implant tooth-supported removable partial denture with at least 15-year long-term follow-up. *Clin Implant Dent Relat Res*. 2015; 17(5):917-22.
35. Zhang B, Dai N, Tian S, Yuan F, Yu Q. The extraction method of tooth preparation margin line based on S-Octree CNN. *Int J Numer Methods Biomed Eng*. 2019; 35(10):e3241.
36. Runte C, Dirksen D, Deleré H, Thomas C, Runte B, Meyer U, et al. Optical data acquisition for computer-assisted design of facial prostheses. *Int J Prosthodont*. 2002; 15(2):129-32.
37. Verdonck HW, Poukens J, Overveld HV, Riediger D. Computer-assisted maxillofacial prosthodontics: a new treatment protocol. *Int J Prosthodont*. 2003; 16(3):326-8.
38. Jiao T, Zhang F, Huang X, Wang C. Design and fabrication of auricular prostheses by CAD/CAM system. *Int J Prosthodont*. 2004; 17(4):460-3.
39. Shen KL, Huang CL, Lin YC, Du JK, Chen FL, Kabasawa Y, et al. Effects of artificial intelligence-assisted dental monitoring intervention in patients with periodontitis: A randomized controlled trial. *J Clin Periodontol*. 2022; 49(10):988-98.
40. Holzinger A, Langs G, Denk H, Zatloukal K, Müller H. Causability and explainability of artificial intelligence in medicine. *Wiley Interdiscip Rev Data Min Knowl Discov*. 2019; 9(4):e1312.
41. Schwendicke F, Singh T, Lee JH, Gaudin R, Chaurasia A, Wiegand T, et al. Artificial intelligence in dental research: Checklist for authors, reviewers, readers. *J Dent*. 2021; 107:103610.