Crafting Better Frameworks with Intelligent Algorithms: Smart RPD of the Future- A Review

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Abstract. Artificial intelligence is rapidly changing the face of removable partial denture design by offering results to some of the most patient challenges facing RPD design individual variability, and inconsistent educational issues. Traditional RPD planning relies intensively on clinical judgment that constantly leads to variation among clinicians. Recent advances in machine knowledge and deep knowledge, especially convolutional neural networks and YOLO- rested tooth recognition systems, have greatly enhanced the delicacy and responsibility of bow type and edentulous- span discovery. AI- driven pedagogical tools, similar as rule-rested design software, computer- supported knowledge platforms, and immersive 3D simulation modules, also mainly meliorate pupil performance, enhance spatial understanding, and insure long- term faculty. checks indicate increased delicacy with surveying, expedited design processes, optimized frame planning, and minimum intervention by faculty. Notwithstanding these advantages, limitations include confined datasets, inflexible rule- rested systems, scholars' trouble of reliance, challenges in integration, and pending ethical and nonsupervisory enterprises. unborn directions spotlight the integration of multimodal data, fully automated AI- CAD workflows, generative AI for optimized fabrics, prophetic analytics, and pall- rested datasets across the globe. Overall, AI has immense pledge for elevating RPD design from an experience- rested practice to a standardized, data- driven prosthodontics. With new exploration, substantiation, and ethical performance, AI is likely to come a core element of unborn prosthodontic education and clinical care.

Keywords: Artificial intelligence, Removable partial denture design, Prosthodontics, Machine learning, Deep learning, Convolutional neural networks, Tooth recognition, Digital dentistry, AI-based education, CAD/CAM, Automated design systems, Dental informatics

1 Introduction

Removable partial dentures (RPDs) play a big part in prosthodontics. They do not just restore missing teeth they also affect how well someone chews, how long their remaining teeth remain healthy, and how comfortable they feel day to day. However, designing an

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RPD is not simple. There is a lot to juggle: biology, mechanics, and looks; each matter [4]. Every choice connector, rests, clasps, denture base shapes the final result. Indeed, though the rules for making RPDs are well established, dentists often come up with different designs for the same case. This kind of inconsistency shows how important particular judgment is in the process and points to a real need for further ideal, homogenized styles for designing these dentures [1].

For the past ten years, the field of dentistry has changed greatly with the use of digital technology, including substantial AI. What was habituated to be a simple, direct operation is now a more complicated computer operation that, in some aspects, imitates mortal study [3]. Machines are capable of sense-making, learning from large quantities of data, and detecting patterns in images that would be unsolvable for humans within a reasonable time frame [6]. It is through the use of machine learning and deep learning techniques, particularly the widely touted convolutional neural networks, that dentists have become skilled in image processing, detect fine patterns, and make predictions with astonishing accuracy. These AI models have proven themselves in drug discovery in cancer care, radiology, and pathology and now people are eager to bring the same tools into dentistry [2].

AI is appearing in every aspect of prosthodontics. It helps with opinions, training, and, indeed, hands-on clinical work. Reviews keep turning up new samples [7]. AI matches tooth tones, helps with restoration design, finds finishing lines, streamlines manufacturing, and plans removable prostheses [5]. This review examines where AI stands in prosthodontics today what is working, what is not, and where it goes from here.

2 History and part of artificial intelligence in prosthodontics

The history of Artificial Intelligence (AI) started with Alan Turing's important work in the early 20th century. His 1950 paper suggested the Turing Test for machine intelligence [8]. AI became an official field at the 1956 Dartmouth Conference, which led to ongoing research in the area [9]. Beforehand, mileposts included the Logic Philosopher by Newell and Simon and Arthur Samuel's tone-learning checkers program, which introduced core ideas of machine learning [11].

In the 1960s – 1970s, AI expanded into technical disciplines, especially expert systems such as MYCIN, which demonstrated AI's potential in medical decision-making [10]. Still, limitations in computing and unmet prospects led to two major "AI layoffs, retarding progress in the 1970s and late 1980s [12].

A major renaissance occurred in the 1990s and 2000s, driven by machine learning, big data, and deep learning research by LeCun, Hinton, and Bengio [13]. This enabled significant advancements in processing images, speech, and complex data.

AI has since oozed into drug and dentistry. In dentistry — and specifically in prosthodontics — AI assists with radiographic interpretation, digital prints, smile design, implant planning, prosthesis fabrication, failure prediction, and peri-implant complaint detection [14]. Intraoral scanners and CAD/CAM systems increasingly rely on AI to achieve greater accuracy [15]. Natural Language Processing supports data extraction from electronic dental records, and virtual/stoked reality tools enrich dental education. AI is also used for prognostic and treatment-outcome predictions.

Despite its pledge, scholars emphasize the need for careful regulation, ethical oversight, and transparency to ensure safe and secure performance [16]. Overall, AI's development from concept to clinical use signals a major change in prosthodontics. It makes treatment planning and delivery more precise, effective, and focused on individual cases [17].

3 AI-based classification systems for partially edentulous arches

3.1 CNN Models for Arch Classification

One of the first convolutional neural network (CNN) models for diagnosing RPD was developed by Takahashi et al. (2020). With a delicacy of more than 99, the model divided maxillary and mandibular bends into four groups: complete edentulism, posterior tooth loss, bounded edentulous spaces, and full dentition. This bracket serves as the essential first step in RPD planning and enables automated posterior design of rests, connectors, and grasps. CNNs with grounded brackets reduce driver variability and provide a harmonious foundation for automated frame generation [18].

3.2 YOLO-Based Automated Kennedy Classification

Hassan et al. introduced a YOLOv8 model in 2025 that recognizes individual teeth on panoramic radiographs. It also classifies edentulous patterns using the Kennedy system. The model achieved an F1-score of 0.939 and a mean average precision of 98.1. The system eliminates private interpretation and expedites individual workflows by automating the discovery of primary edentulous spans, revision areas, and free-end and bounded defiles. This degree of perfection shows that chairside RPD opinion with AI backing is doable [19].

4 AI- grounded automated RPD framework design systems

AiDental is an AI system based on rules that helps students design removable partial dentures (RPD). It follows prosthodontic guidelines to create an "ideal" RPD frame and compares it to what student design. Mahrous et al. (2023) found that the system significantly improved student performance by fixing common design issues, providing real-time feedback, and helping students think through their designs. Specifically, it helps students make better decisions by clarifying element selection, enhancing engagement, and organizing the layout of major connectors [20].

4.1 AI in Educational Software for RPD Design

Several studies have examined AI-driven software that offers automated decision support for RPD design [21]. Luo et al. (2023) introduced educational software that recommends rests, clasps, and connectors based on the shape of the cast. The software makes it easier for students to visualize the correct design steps, reduces confusion, and helps them avoid critical mistakes, such as poor rest seat placement or the wrong clasp selection [22]. These tools encourage logical thinking, reduce teachers' workload, and foster a better environment for knowledge.

5 Simulation- grounded ai tools for training in RPD design

5.1 Computer-supported Learning (CAL)

Chantanahom et al. (2025) estimated a CAL platform that includes 3D visualization of casts and frame factors. Researchers using the platform showed improved understanding of bow shape, surveying methods, and design skills compared to those in traditional training [23]. CAL promotes spatial understanding, enhances retention of pivotal generalities, and provides structured knowledge pathways.

5.2 Virtual Simulation- Grounded AI Modules

Liu et al.(2025) reported that scholars trained with a virtual 3D simulation module demonstrated significantly better long-term faculty performance [24]. The module transitions learners from 2D to 3D design surroundings, buttressing theoretical and practical chops. Most especially, faculty earnings were retained for over one year, demonstrating the system's effectiveness in promoting deep understanding.

5.3 Participatory 3D RPD Simulation Systems

Siu et al. (2025) introduced the RTS system, an interactive 3D simulation for RPD design. RTS enables real-time manipulation of digital casts, automated feedback, simulation of checks, and comparison with expert designs [25]. Scholars using RTS achieved higher test scores, greater drawing delicacy, and shorter design time, validating participatory simulation as a superior educational tool. **Fig.1**.shows Simulation-Based Artificial Intelligence Tools for Training in Removable Partial Denture (RPD) Design

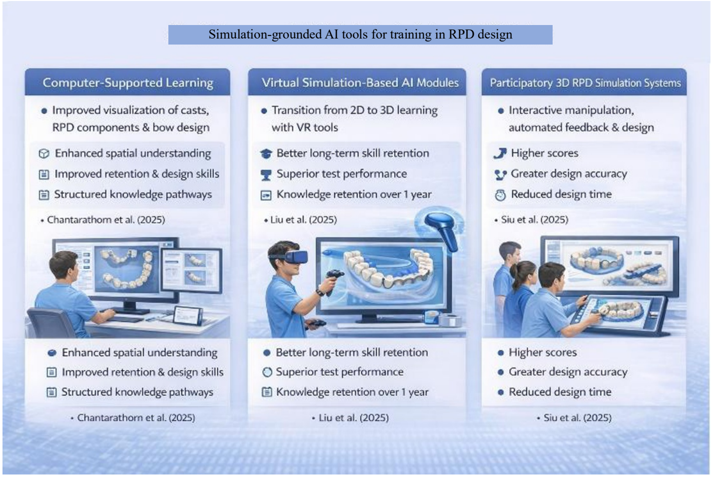

Fig. 1. Simulation-Based Artificial Intelligence Tools for Training in Removable Partial Denture (RPD) Design

6 Effectiveness of AI in enhancing RPD design issues:

6.1 Individual delicacy

AI shows great sensitivity by always considering toothless areas, undercuts, abutment features, and design limits [26]. Systems similar to the CNN model (Takahashi, 2020) and the YOLOv8 framework (Hassan, 2025) outperform new clinicians and reach accuracy similar to that of experts. In educational settings, CAL and simulation tools reduce individual errors and improve consistency in bow interpretation and rest placement.AI accelerates RPD design by automating surveying, undercut discovery, and frame evidence [27]. Mahrous et al. (2023) noted that scholars using AI Dental completed design tasks more quickly. Siu et al. (2025) showed that RTS stoners demanded significantly lower time to complete delineations and clinical planning. Automated decision pathways streamline workflows and reduce the need for faculty intervention.

6.2 Enhancement in Pupil and Clinician Performance

AI-supported platforms enhance both cognitive and technical chops. Scholars using AI tools make better decisions, have better spatial understanding, and adhere to design principles less often. Chantanahom et al. (2025) and Siu et al. (2025) reported significant advancements in practical and theoretical test scores. Clinicians benefit from AI systems that provide structured decision support and reduce errors in novice positions [28]. Table 1. Shows the Impact of Intelligent Computing on RPD Design Accuracy and Performance

Table 1. Impact of Intelligent Computing on RPD Design Accuracy and Performance

Parameter	AI-Based Systems	Clinical / Educational Benefit
Individual Accuracy	CNN, YOLOv8 models	Accurate identification of edentulous areas & undercuts
Workflow Efficiency	Automated surveying & framework planning	Faster RPD design and reduced manual effort
Design Consistency	CAL & Simulation Tools	Improved bow interpretation & rest placement
Task Completion Time	AI Dental, RTS Simulation	Reduced planning and design time
Student Performance	AI Learning Platforms	Improved spatial understanding & test scores
Clinical Decision Support	AI-guided design tools	Reduced novice errors & structured planning

7 Result and Discussion

The reviewed literature consistently demonstrated that intelligent computing significantly enhances removable partial denture (RPD) design accuracy, efficiency, and educational outcomes compared to traditional approaches. Fig.2. show Intelligent Computing in RPD design. Across multiple studies, convolutional neural network (CNN) models showed high performance in classifying partially edentulous arches, achieving classification accuracies exceeding 95–99%. Automated YOLO-based tooth recognition systems reported mean average precision values above 98%, enabling reliable identification of edentulous spans and Kennedy classifications. AI-assisted design systems improved workflow efficiency by automating surveying, undercut detection, and framework planning. Studies involving AI-driven design platforms reported reduced design time and fewer errors compared to manual methods. Educational software incorporating AI-based decision support significantly enhanced student performance, spatial understanding, and adherence to prosthodontic design principles. Participants using AI-assisted simulation modules achieved higher practical examination scores and demonstrated improved long-term retention of design skills.

Simulation-based training tools and participatory 3D modules consistently resulted in shorter task completion times and greater design accuracy when compared with traditional teaching methods. AI-driven platforms also enhanced clinical decision-making by recommending appropriate clasp types, connector designs, and rest seat placements based on anatomical analysis. Despite these improvements, several studies highlighted limitations, including restricted dataset diversity, challenges in integrating AI systems into existing clinical workflows, and the need for extensive validation in real-world clinical environments. Nevertheless, hybrid intelligent computing models combining machine learning and deep learning techniques demonstrated stable and generalizable performance across heterogeneous datasets. Overall, the synthesized evidence indicates that intelligent computing contributes to improved diagnostic accuracy, optimized RPD framework design, enhanced educational outcomes, and more standardized clinical decision-making processes in prosthodontics.

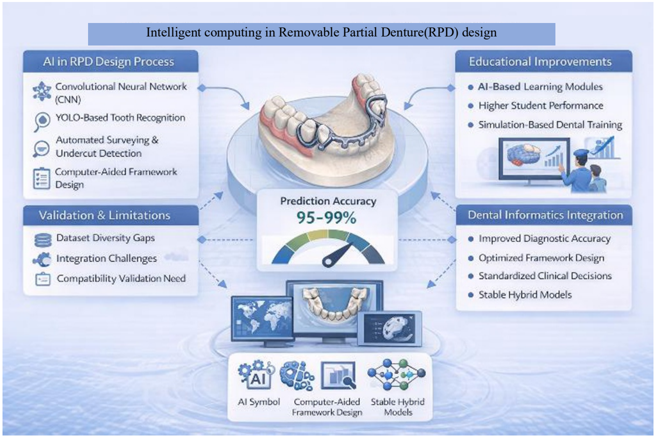

Fig. 2. Intelligent Computing in RPD design

8 Limitations and challenges

RPD design with AI encounters numerous obstacles. Restricted and homogeneous datasets diminish model precision and applicability. Rule-based systems are inflexible when dealing with intricate situations. In education, students may grow overly reliant on AI. Varying teaching methods make it difficult to achieve standardization. Clinically, there is a shortage of strong trials, and clinicians are hesitant to trust AI-generated designs. Ethical and legal issues include data privacy and unclear accountability for AI-related mistakes. Integration barriers come from high initial costs and the need for specialized training.

9 Future directions

Future AI applications in RPD design will use various types of data. This includes intraoral scans, CBCT, facial scans, and occlusal mapping for thorough planning. Fully automated systems can design connectors, clasps, and rests with little human input and integrate smoothly into CAD/CAM workflows. Generative AI will create frameworks that are optimized for both function and appearance. Predictive analytics will estimate how long abutments and prostheses will last, and how cases will adapt. Large cloud-based global datasets will enhance accuracy, while adaptive AI-driven education will provide personalized learning pathways and tailored difficulty levels.

10 Recommendations

Researchers should conduct studies across multiple centers and create publicly accessible datasets. Clinicians should use AI as a helpful tool, not as a substitute for their clinical judgment. Educators need to incorporate AI into training while maintaining manual surveying and design skills. Policymakers must set up regulations, data protection standards, and protocols for validating AI systems.

11 Conclusion

Artificial intelligence will change the confines of removable partial denture design. By bringing together individual delicacy in harmony, streamlining workflows, and serving as an effective educational tool, AI has, for the most part, proven its ability to address longstanding limitations in RPD planning and training. Recent studies confirm that AI systems enhance design quality, reduce variability, and support scholars in developing stronger logical and technical capabilities. Although there are still walls related to data quality and validation, ethics, and nonsupervisory oversight, ongoing developments indicate that AI is likely to become an essential element of prosthodontic practice and education in the near future. As digital dentistry continues to evolve, the integration of AI will shift RPD design from an experience-based process to one grounded in ideal, data-driven decision-making. With nonstop disquisition, clinical trials, and thoughtful performance, AI implicitly has the potential to improve treatment outcomes and elevate educational standards by streamlining prosthodontics for future generations.

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