

IMPLICATIONS OF ARTIFICIAL INTELLIGENCE IN THE FABRICATION OF REMOVABLE DENTAL PROSTHESES WITH ENHANCED ESTHETICS- A NARRATIVE REVIEW

Filip Alexandru¹, Ionela Racaru¹ Forna Norina²

1 DDS, Resident, Faculty of Dental Medicine, University of Medicine and Pharmacy "Grigore T.Popa", Iasi
2 "Gr. T. Popa" U.M.Ph. - Iasi, Romania, Faculty of Dentistry, Department of Implantology, Removable Dentures, Dentures Technology

Corresponding authors: Ionela Racaru, e-mail: ionelaracaru@yahoo.com

ABSTRACT

Artificial intelligence (AI) is increasingly influencing prosthodontics by supporting diagnosis, digital design, tooth arrangement, facial analysis and computer-aided fabrication. This narrative review evaluates the implications of AI in the fabrication of removable dental prostheses with enhanced esthetics, with emphasis on complete dentures and removable partial dentures. A structured search was performed in PubMed, Google Scholar, ScienceDirect, Web of Science and publisher databases for articles published between 2018 and 2026. Search terms included "artificial intelligence", "machine learning", "deep learning", "removable prosthodontics", "complete denture", "removable partial denture", "digital denture", "CAD/CAM" and "digital smile design". The selected literature indicates that AI can automate or assist arch classification, RPD framework design, virtual tooth arrangement, occlusal assessment, smile analysis and color/esthetic prediction. The most clinically relevant benefit is not full automation, but a human-in-the-loop workflow that combines algorithmic recommendations with prosthodontic judgement. Current limitations include small datasets, insufficient external validation, dataset bias, lack of standardized outcome measures and limited evidence from long-term clinical trials. AI-assisted removable prosthodontics is therefore promising for improving esthetic predictability and workflow efficiency, but its routine use should remain supervised by clinicians until stronger evidence is available.

Key words: artificial intelligence, removable prosthodontics, complete denture, removable partial denture, CAD/CAM, digital smile design, esthetics

INTRODUCTION

Removable dental prostheses remain essential treatment options for partially and completely edentulous patients. Although implant-supported rehabilitation has expanded, complete dentures and removable partial dentures continue to be widely used because they are less invasive, more affordable and suitable for patients with anatomical, systemic or financial limitations. Their esthetic success depends on a complex balance between denture base extension, tooth morphology, tooth arrangement, lip support, smile line, gingival display, occlusal plane orientation and patient-specific facial features.

Conventional removable prosthesis fabrication relies on manual procedures and the subjective experience of dentists and dental technicians. Artificial tooth arrangement in complete dentures and the design of RPD components can vary substantially between operators. The introduction of intraoral scanning, facial scanning, virtual

articulation, CAD/CAM milling and 3D printing has improved reproducibility, but digital workflows still require time-consuming manual design steps. AI is now being investigated as a method for converting clinical data into predictive design recommendations.

In prosthodontics, AI refers mainly to machine learning, deep learning, computer vision and expert systems used to recognize anatomical patterns, classify edentulous arches, identify landmarks, propose tooth positions, assist shade and esthetic evaluation, optimize frameworks and support manufacturing. Recent reviews report that AI has already been tested for tooth shade selection, restoration design, removable partial denture design and prediction of facial changes in patients with removable prostheses. However, most systems are still experimental or assistive rather than autonomous.

MATERIAL AND METHODS

A narrative literature review was conducted in accordance with the structure required by the Romanian Journal of Medical and Dental Education model. The search was performed using PubMed, ScienceDirect, Web of Science, Scopus-indexed publisher pages, Google Scholar and open-access full-text databases. The search period covered 2018–2026, with priority given to recent peer-reviewed studies and reviews published between 2021 and 2026.

The following combinations of keywords were used: “artificial intelligence in prosthodontics”, “prostheses. Editorials without technical or clinical content, non-English papers and articles with no prosthodontic relevance were excluded.

Data extraction focused on: study type, AI method, prosthodontic application, relevance to

“AI removable prosthodontics”, “machine learning removable dentures”, “complete denture tooth arrangement AI”, “removable partial denture design artificial intelligence”, “CAD/CAM digital denture esthetics”, “digital smile design artificial intelligence” and “facial analysis prosthodontics AI”. Articles were included if they addressed AI, machine learning, deep learning, digital prosthodontics, denture design, RPD framework design, esthetic analysis or CAD/CAM workflows relevant to removable

removable prostheses, esthetic contribution, reported advantages and limitations. The review was intentionally narrative rather than meta-analytic because available studies are heterogeneous in methodology, datasets, outcomes and validation protocols.

Table I. Main scientific sources extracted and integrated in the review

Author / year	AI application	Extracted scientific contribution	DOI link
Revilla-León et al., 2023	AI in fixed and removable prosthodontics	Systematic review showing potential for shade selection, restoration design, facial-change prediction and RPD design; clinical performance still requires validation.	10.1016/j.prosdent.2021.06.001
Ali et al., 2024	AI in removable prosthodontics	Review of 15 studies; AI was applied to RPD design, arch classification, complete denture outcome prediction, maxillofacial prostheses and denture tooth material prediction.	10.2186/jpr.JPR_D_23_00073
Dai et al., 2018	Complete denture tooth arrangement	Rule-driven digital tooth arrangement combined patient scans, individualized constraints and virtual occlusal adjustment to improve automated complete denture design.	10.1371/journal.pone.0198252
Takahashi et al., 2021	RPD arch classification	CNN-based classification of partially edentulous arches as an initial step for AI-assisted RPD design.	10.2186/jpr.JPOR_2019_354
Mahrous et al., 2023	AI and RPD education/design	AiDental software improved learning and standardized RPD design decisions in preclinical education.	10.1002/jdd.13225
Li et al., 2026	Explainable AI for RPD major connectors	CNN system trained on 1000 specialist-designed RPDs to generate clinically logical major connector recommendations with Grad-CAM explainability.	10.2186/jpr.JPR_D_25_00183
Ceylan et al., 2023	AI digital smile design	Compared AI-generated and manually created smile designs and showed that esthetic preference depends on case complexity and evaluator background.	10.3390/app13159001
Aljulayfi et al., 2024	Comprehensive AI review	Summarized AI roles in prosthodontic diagnosis, planning, manufacturing and clinical	10.12659/MSM.944310

		decision support, emphasizing validation and ethical concerns.	
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RESULTS AND DISCUSSIONS

3.1 AI in the design of removable prostheses

The design of removable prostheses is one of the most relevant areas for AI integration because it involves repeated pattern-recognition tasks. In complete dentures, artificial tooth arrangement depends on the occlusal plane, arch form, alveolar crest morphology, esthetic lip line and interarch relationship. Dai et al. proposed an automated complete denture tooth arrangement approach that uses patient-specific 3D data, individualized anatomical constraints, an artificial tooth database, rule-driven positioning and virtual occlusal adjustment. This study is important because it demonstrates how traditional prosthodontic rules can be translated into a digital algorithm capable of producing individualized arrangements.

For removable partial dentures, AI has been used to classify partially edentulous arches and support framework design. Takahashi et al.

3.2 AI and CAD/CAM integration

Digital denture workflows combine scanning, CAD design, milling or additive manufacturing. AI can be inserted into this workflow at multiple points: segmentation of oral structures, detection of undercuts, occlusal plane estimation, automatic tooth library selection, tooth arrangement, framework design and quality control. Reviews in prosthodontics report that AI models have already been tested for restoration design, tooth shade selection, RPD design and prediction of treatment-related changes.

In CAD/CAM removable prosthodontics, AI is most useful when it reduces repetitive manual steps. For example, an AI system may propose a preliminary tooth arrangement or RPD framework

developed a CNN method for classifying dental arch images as part of an AI system for RPD design. More recently, Li et al. developed an explainable CNN-based system for major connector design using 1000 specialist-designed RPDs and 255 dental variables. The model followed clinical logic by predicting denture type, unilateral or bilateral design and the presence and type of major connector. Such systems are valuable because RPD design remains difficult to standardize and is strongly influenced by the experience of the clinician.

The evidence suggests that AI can reduce variability in design proposals, but it cannot replace clinical reasoning. The final prosthesis must still be checked for support, stability, retention, indirect retention, path of insertion, tissue tolerance, occlusal harmony and patient-specific esthetic expectations.

that the clinician then edits. This shortens the design phase and can improve reproducibility between technicians. However, manufacturing accuracy still depends on scanner precision, material behavior, printing or milling parameters, post-processing, bonding between denture base and teeth and final clinical adjustment.

AI-supported manufacturing should therefore be understood as a supervised digital chain rather than a fully autonomous process. The main clinical advantage is the possibility of generating a more consistent first design, followed by faster try-in, easier communication with the patient and more predictable esthetic modifications

3.3 Aesthetic optimization through AI

Esthetics in removable prosthodontics is not limited to tooth color or shape. Complete denture

esthetics require restoration of facial support, correct anterior tooth display, adequate vertical dimension, pleasing smile curvature, natural gingival architecture and harmony with age, sex

and facial proportions. AI-based facial analysis and digital smile design systems may help clinicians evaluate midline, smile line, incisal edge position, buccal corridor, facial flow and tooth proportions.

Ceylan et al. compared AI-generated and professionally created digital smile designs and found that preference varied by case and evaluator group. This finding is clinically relevant for removable prostheses because esthetic acceptability is subjective and depends on both professional criteria and patient perception. AI can provide a rapid esthetic proposal, but it should not impose a single “ideal” design. Instead, it should support a shared decision-making process in which the patient can visualize and choose among alternatives.

For complete dentures, AI-assisted esthetic planning could integrate facial photographs, 3D facial scans, intraoral scans and digital tooth libraries. The system may suggest tooth width, incisal edge position, gingival display and arch form. In elderly edentulous patients, this approach may also help avoid over-standardized designs by adapting the prosthesis to facial aging, lip dynamics and individual expectations.

3.4 AI in digital denture workflow

A clinically realistic AI-assisted workflow begins with acquisition of intraoral or cast scans,

jaw relation records, facial photographs or facial scans and patient esthetic preferences. The AI module analyzes anatomical and facial data, classifies the clinical situation, proposes a denture base or RPD framework and selects tooth morphology and arrangement. A virtual articulator and occlusal analysis are then used to detect interferences and verify function. The clinician reviews the design, modifies it if necessary, communicates the esthetic preview to the patient and sends the final design to milling or 3D printing.

This workflow is particularly useful in complex cases where esthetics and function must be planned simultaneously. For example, maxillary anterior tooth arrangement can be adjusted according to lip support and smile line, while posterior tooth position can be optimized for ridge support and balanced occlusion. AI may also help identify design inconsistencies before manufacturing, reducing remakes and chairside corrections.

Educational studies also support the usefulness of AI-based systems. Mahrous et al. evaluated AI and game-based learning in RPD design education using AiDental software. Although the context was educational, the findings are relevant to clinical practice because they show that AI can standardize decision pathways and provide structured feedback for design choices.

AI-assisted digital workflow for esthetic removable prostheses

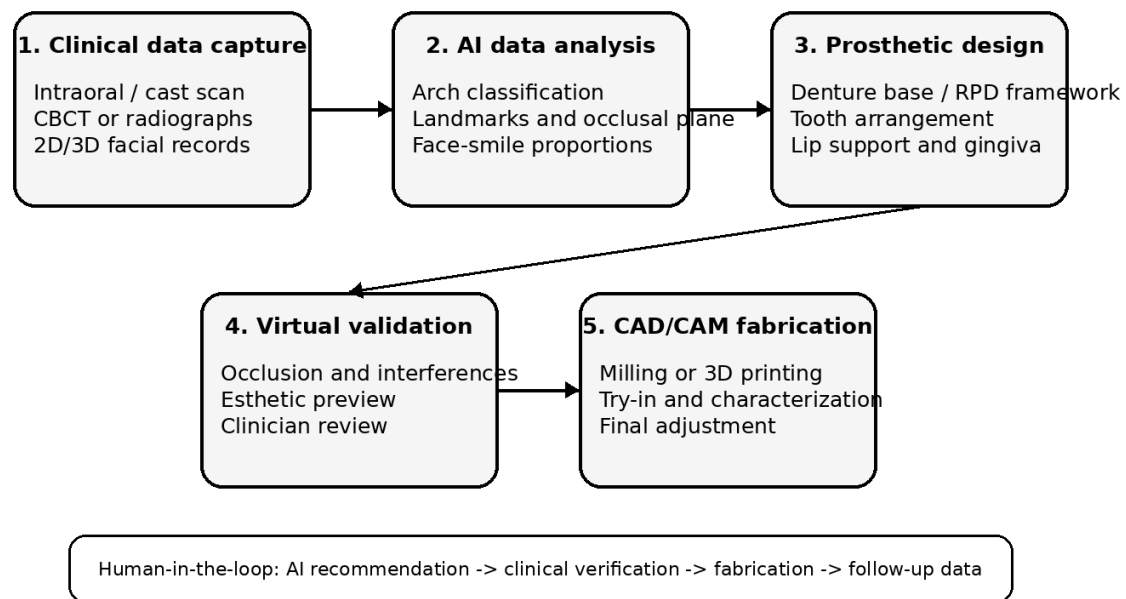


Figure 1. AI-assisted digital workflow for esthetic removable dental prostheses.

3.5 Limitations and challenges

Despite rapid progress, AI in removable prosthodontics still has important limitations. The first limitation is the scarcity of large, diverse and clinically validated datasets. Many models are trained on institutional data, which may not represent different populations, skeletal patterns, edentulous ridge conditions, materials or operator philosophies. A model trained on a limited dataset may reproduce local design preferences rather than universal prosthodontic principles.

The second limitation is the lack of external validation and long-term clinical outcomes. A digital design may appear accurate in software but still fail clinically because of tissue displacement, saliva, muscular control, patient adaptation, denture base deformation, printing shrinkage or occlusal changes. For esthetic outcomes, patient-reported satisfaction should be considered alongside professional ratings.

The third limitation concerns responsibility and ethics. AI-generated designs may influence treatment decisions, but the clinician remains responsible for diagnosis, consent, design

approval and follow-up. Transparent systems, explainable outputs, data protection and bias control are essential before AI can be routinely integrated into prosthodontic decision-making.

CONCLUSIONS

1. Artificial intelligence represents a significant technological advancement in removable prosthodontics, particularly for digital design, arch classification, tooth arrangement, RPD framework planning and esthetic analysis.

2. Current evidence supports the use of AI as an assistive tool that can increase efficiency, reproducibility and personalization, but not as a replacement for clinical prosthodontic judgement.

3. AI-assisted digital workflows may improve esthetic outcomes by integrating facial analysis, smile design, tooth morphology selection, lip support and virtual visualization before fabrication.

4. The most promising model is a human-in-the-loop workflow in which AI generates preliminary designs and the clinician verifies

biological, biomechanical, functional and esthetic suitability.

5. Future research should focus on multicenter datasets, standardized outcome measures, external validation, patient-reported esthetic satisfaction and long-term clinical performance of AI-designed removable prostheses.

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