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Review Article

Digital Evolution in Removable Prosthodontics: The Expanding Role of 3D Printing Technologies

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Abstract

Recent advances in digital dentistry have significantly influenced the fabrication of various prosthodontic appliances. Three-dimensional (3D) printing, also known as additive manufacturing, has emerged as a transformative technology within removable prosthodontics, offering enhanced efficiency, improved strength, reduced chairside time, superior accuracy and precision of fit, minimal material wastage, and cost-effective methods for producing dentures, impression trays, and frameworks.
This review explores the evolution of 3D printing technologies and materials used in removable prostheses, highlights clinical applications and outcomes, discusses comparative advantages in cost and time efficiency, and identifies current challenges and future directions. It also provides insight into the growing role of 3D printing in the design and fabrication of removable dental prostheses, including both complete and partial dentures.
The integration of digital workflows with additive manufacturing represents a significant paradigm shift in prosthodontic practice, contributing to improved patient care, enhanced predictability, and greater clinical efficiency.

Keywords: *3D printing, additive manufacturing, CAD/CAM, cost efficiency, dental materials, digital dentures, removable prosthodontics.*

INTRODUCTION

The global demand for prosthodontic services is rising rapidly, driven by demographic aging and a growing prevalence of oral diseases. These trends underscore the critical role of prosthodontics in restoring oral function, esthetics, and masticatory efficiency through tooth replacement. Among prosthodontic modalities, removable prosthodontics remains a cornerstone: removable dentures offer a flexible, patient-manageable solution for both fully and partially edentulous individuals.[1]

However, conventional denture fabrication remains complex and technique-sensitive. The traditional workflow typically involves multiple clinical and laboratory appointments, manual steps such as border molding and flasking, and is susceptible to operator variability. These factors often lead to inconsistencies in fit, comfort, and treatment duration.[2]

In recent years, digital dentistry—particularly three-dimensional (3D) printing—has begun to transform the removable prosthodontics workflow (Figure 1). By integrating computer-aided design (CAD) with additive manufacturing, 3D printing enables precise, reproducible, and highly customizable denture fabrication (Figure 2).[3] Compared to subtractive milling or conventional flasking, additive workflows offer reduced material wastage, lower production costs, shorter clinical time, and improved patient-centered outcomes.[4]

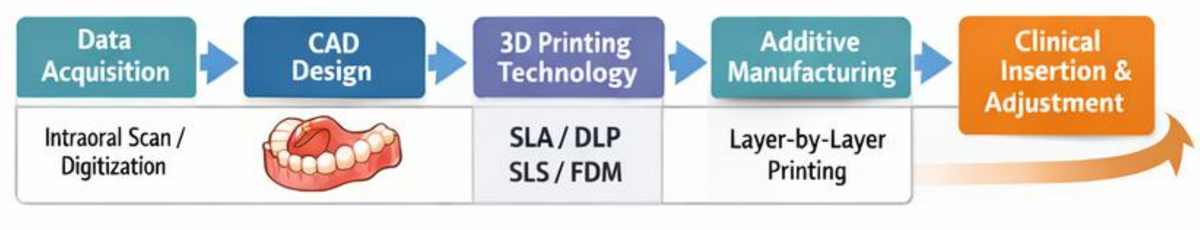

Figure 1. Digital workflow in three-dimensional (3D) printed prosthodontics.

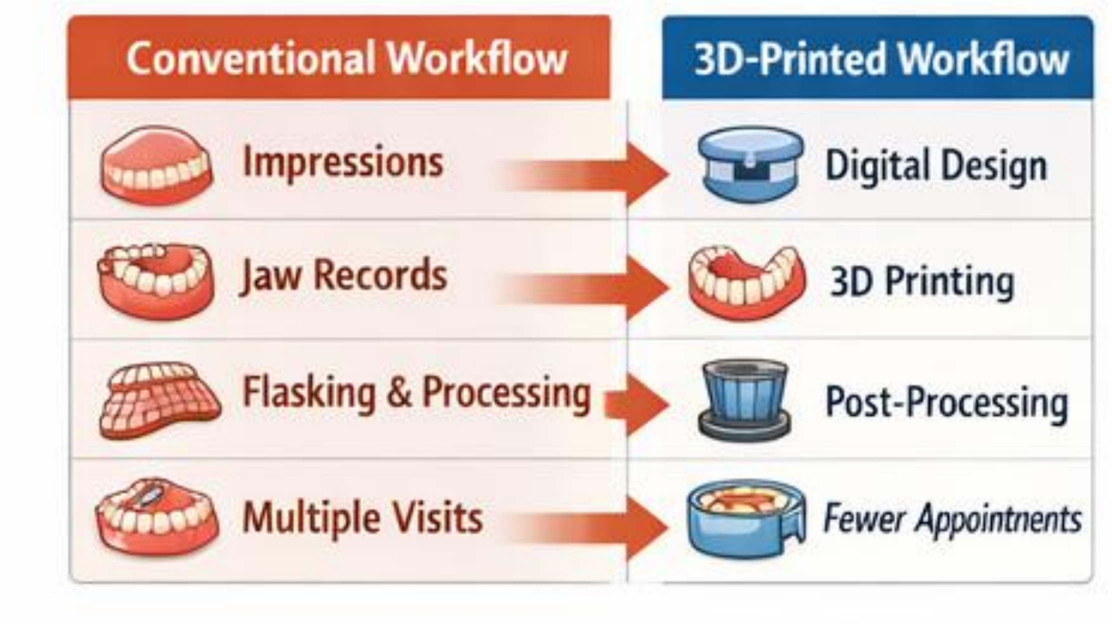

Figure 2. Methods of denture fabrication, illustrating conventional, CAD/CAM milling, and additive manufacturing approaches.

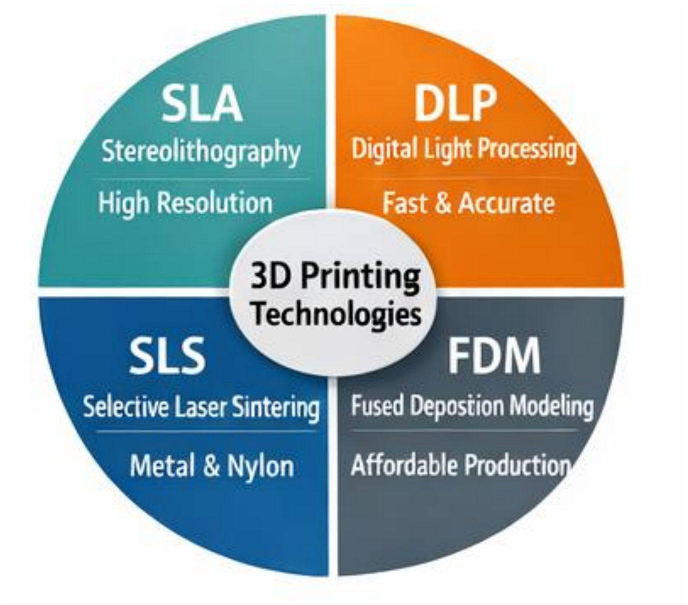

Figure 3. Three-dimensional (3D) printing technologies employed in prosthodontics.

3D printing technologies (Figure 3) have matured significantly. Techniques such as stereolithography (SLA) and digital light processing (DLP) provide high-resolution resin curing, while selective laser sintering (SLS) and fused deposition modeling (FDM) each offer unique material advantages.[5] Table 1 provides an overview of the most commonly used 3D printing technologies in removable prosthodontics, describing their working principles, clinical advantages, limitations, and suitability for denture fabrication.

Table 1. Overview of Common 3D Printing Technologies Used in Removable Prosthodontics

Technology	Mechanism	Common Materials	Advantages	Limitations
SLA	Photopolymerization using laser	Photopolymer resins	High accuracy, smooth finish	Resin brittleness
DLP	Layer curing via projected light	Photopolymer resins	Fast, good detail	Limited build size
SLS	Laser fuses powder	Nylon/polyamide	Strong, durable	Rough surface
FDM	Thermoplastic extrusion	PLA/ABS	Low cost	Low resolution

The range of materials available for additive manufacturing in denture prosthodontics is also expanding—from rigid and flexible photopolymer resins to hybrid resin composites, PMMA-based printable materials, and polyamide powders (Figure 4).[6]

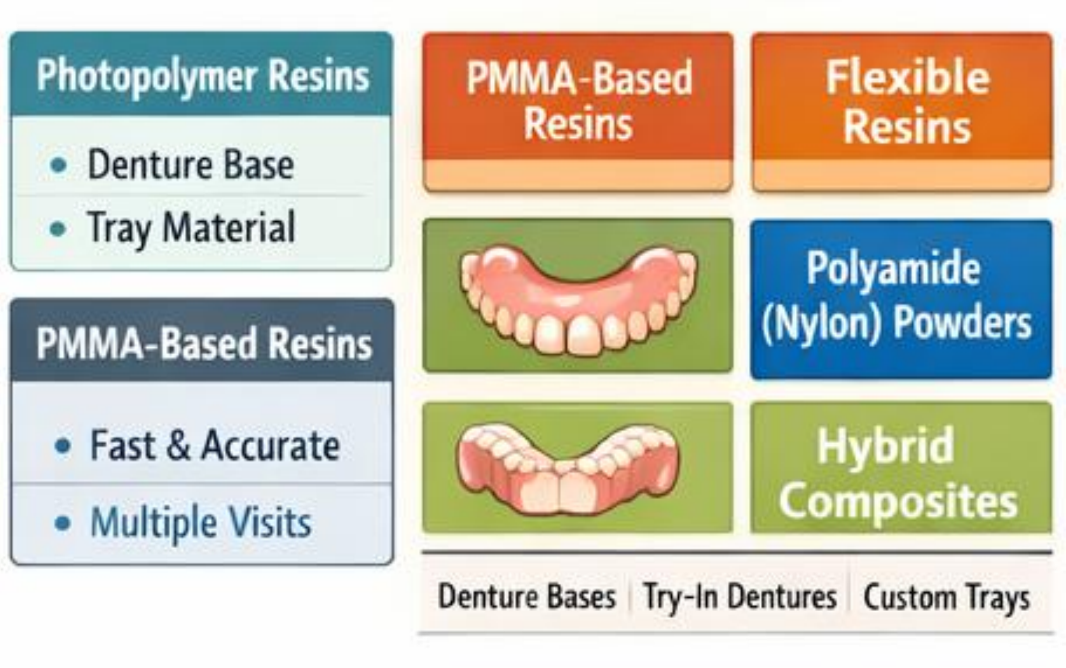

Figure 4. Materials commonly used for three-dimensional (3D) printed denture fabrication.

Table 2 summarizes the key printable materials used in denture fabrication, including their composition, mechanical performance, biocompatibility, esthetic attributes, and clinical indications.

Table 2. Materials Commonly Used in 3D-Printed Dentures

Material Type	Examples	Key Properties	Clinical Relevance
Photopolymer Resins	DLP/SLA resins	High accuracy	Used for dentures & try-ins
Hybrid Resin Composites	Resin + fillers	High strength	Improved wear resistance
PMMA-Based Resins	Printable PMMA	Biocompatible	Alternative to heat-cured PMMA
Polyamide Powders	Nylon	Tough, flexible	Frameworks & flexible bases
Reinforced Resins	Nano-reinforced	Higher strength	Emerging use

Clinical research to date offers promising yet early-stage evidence. Multiple studies report that 3D-printed complete dentures can achieve comparable retention and adaptation to conventional dentures, with shorter production timelines.[7] Systematic reviews indicate that digital dentures may provide improved retention, fewer appointments, and favorable patient satisfaction, although concerns persist regarding esthetics and phonetics.[8] Table 3 presents a comparison of clinical outcomes between 3D-printed and conventionally fabricated dentures, focusing on parameters such as fit accuracy, comfort, esthetics, masticatory performance, and durability.

Table 3. Clinical Outcomes of 3D-Printed vs. Conventional Dentures

Outcome Measure	3D-Printed Dentures	Conventional Dentures
Retention / Fit	Comparable	Consistently good
Adaptation	Acceptable	Higher consistency
Patient Comfort	Good	Preferred by some
Aesthetics/Phonetics	Acceptable	Often preferred
Microbial Adhesion	Lower	Higher
Appointments	Fewer	Multiple
Failures	Slightly higher	Lower

Despite promising advances, several challenges remain. Printer resolution may affect fine detailing, photopolymer resins can be brittle, and long-term data on fatigue behavior are still limited. Additionally, high initial costs for equipment and training, as well as regulatory and standardization barriers, hinder widespread adoption (Figure 5).[9]

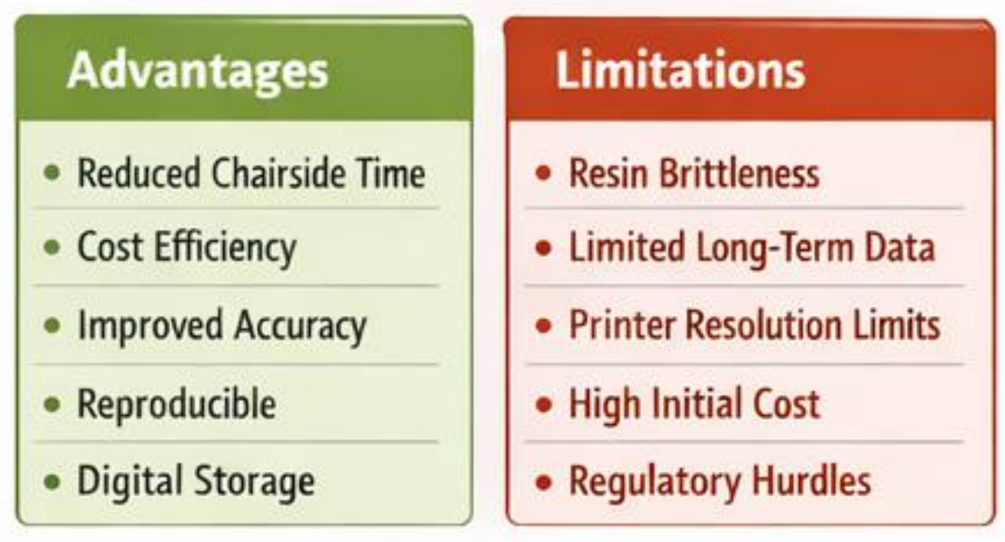

Figure 5. Advantages and limitations of three-dimensional (3D) printed prostheses.

Table 5 outlines these major clinical, technical, and regulatory limitations associated with 3D-printed dentures.

Looking to the future, innovations such as multi-material printing, artificial intelligence–driven design tools, sustainable materials, and automated workflows promise to further enhance the accessibility, efficiency, and quality of digital removable prosthodontics (Figure 6)

Figure 6. Emerging trends and future directions in three-dimensional (3D) printed prosthodontics.

These emerging trends and future directions are summarized in Table 6.

DISCUSSION

The integration of 3D printing into removable prosthodontics represents a paradigm shift. Clinical studies and patient-reported outcomes increasingly support the viability of printed dentures, yet several practical limitations remain.

Clinical Performance and Fit

Several studies demonstrate that 3D-printed dentures can match conventional dentures in terms of retention, adaptation, and overall fit. For example, a comparative clinical study found no significant difference in retention and denture base adaptation between 3D-printed and conventionally fabricated complete dentures over six months.[10] This suggests that additive manufacturing using high-quality dimethacrylate-based resins can achieve acceptable trueness and clinical stability.

A narrative review also reported comparable, and in some instances, superior retention and comfort for 3D-printed dentures. This may be attributed to reduced polymerization shrinkage in printed bases and enhanced internal fit.[11] However, the review noted that dentures fabricated via conventional impressions followed by digitization achieved better retention than dentures produced entirely through digital impressions.[12]

Patient Satisfaction and Microbial Considerations

Although overall patient satisfaction with 3D-printed dentures is favorable, some studies show a preference for conventional dentures in terms of stability, comfort, and phonetics.[13] In a randomized crossover trial, patients rated conventional dentures higher in these domains, though printed dentures required fewer adjustments and offered faster fabrication times.[14]

From a microbiological perspective, emerging evidence is encouraging. A randomized crossover clinical trial demonstrated significantly lower microbial colonization on 3D-printed CAD/CAM dentures over a three-month period compared to conventional dentures.[15] This may have implications for hygiene maintenance, candida control, and long-term oral health.

Efficiency, Cost, and Digital Workflow Advantages

One of the strongest arguments for 3D-printed dentures involves workflow efficiency and cost-effectiveness. A systematic review and meta-analysis concluded that CAD/CAM dentures (milled and printed) offer improved retention, fewer appointments, and reduced working time compared to conventional dentures.[16]

In implant overdentures as well, 3D printing shows promise. A crossover clinical study on mandibular implant-supported overdentures found that 3D-printed prostheses demonstrated similar masticatory performance and patient satisfaction compared to traditionally processed dentures, aside from a slight esthetic preference for conventional acrylic.[17]

Table 4 provides a comparative analysis of cost and time efficiency between 3D-printed and traditional denture workflows, highlighting areas where digital techniques improve productivity and reduce expenses.

Table 4. Cost and Time Efficiency Comparison

Parameter	3D Printing Workflow	Conventional Workflow
Material Waste	Low	High
Labor Requirements	Low	High
Visits Required	2–3	4–5
Production Time	Fast	Slow
Cost Efficiency	High	Lower

Limitations and Challenges

Despite its advantages, 3D-printed removable prosthodontics is limited by several factors:

1. **Mechanical Properties and Durability:** Pilot RCTs show instances of material fracture and tooth debonding in printed dentures, raising concerns regarding resin brittleness and long-term fatigue resistance.[18]
2. **Printer Resolution and Trueness:** Limited resolution may affect peripheral seal, border formation, and occlusal balance. Clinical studies have noted discrepancies in intaglio surface trueness compared to conventional bases.[19]
3. **Patient-Reported Trade-offs:** While digital workflows reduce visits, some patients still prefer the esthetics and phonetics of conventional dentures.[20]
4. **Regulatory and Standardization Barriers:** Diverse resin types, printer systems, and post-processing protocols complicate standardization and regulatory approval.
5. **Cost and Training:** Significant initial investments may limit adoption in low-volume clinical settings.

Table 5 comprehensively presents these limitations and their clinical implications.

Table 5. Limitations and Challenges of 3D-Printed Dentures

Category	Specific Challenges
Material-Related	Brittleness, limited long-term data
Technical	Resolution limits, inaccuracies
Aesthetic	Shade limitations
Patient Issues	Speech concerns
Logistical	Equipment cost, training
Regulatory	Need for standardization

Future Directions

Advances that are expected to further elevate the field include:

- Development of reinforced resins using nano-fillers such as TiO_2 or ZrO_2.[21]
- Multi-material printing capable of producing flexible bases and rigid teeth in the same build.
- Artificial intelligence–assisted denture design and automated error-prediction.
- Eco-friendly, recyclable, and sustainable resin systems.
- Long-term randomized clinical trials assessing durability, maintenance needs, and quality-of-life outcomes.

Table 6. Future Directions in 3D Printing for Prosthodontics

Development Area	**Potential Advancements**
Materials	Multi-material printing
Design Optimization	AI-assisted planning
Workflow Automation	Full digital integration
Clinical Enhancements	Improved occlusal schemes
Sustainability	Eco-friendly materials

Table 6 discusses these emerging trends and anticipated innovations, while Table 7 provides a detailed comparison of different 3D printing technologies specifically for denture base fabrication—focusing on accuracy, surface finish, strength, biocompatibility, processing time, and cost implications.

Table 7. Comparison of 3D Printing Technologies for Denture Bases

Parameter	SLA/DLP	SLS	FDM
Accuracy	High	Moderate	Low
Surface Finish	Smooth	Rough	Visible lines
Strength	Moderate	High	Moderate
Best Use	Final dentures	Frameworks	Prototyping
Cost	Moderate	High	Low

CONCLUSION

3D printing is poised to revolutionize removable prosthodontics by offering more precise, efficient, and patient-tailored workflows. Clinical evidence to date suggests that 3D-printed dentures can rival conventional prostheses in terms of retention, comfort, and microbial performance, while reducing fabrication time and visits. However, limitations related to material strength, resolution, aesthetics, and long-term durability must be addressed before widespread adoption can be realized. Future advances in materials, design automation, and clinical validation are likely to cement the role of 3D printing as a mainstream modality in denture fabrication.

REFERENCES

1. Abdelnabi, M. H., & Swelem, A. A. (2024). 3D-printed complete dentures: A review of clinical and patient-based outcomes. *Cureus, 16*(9), e69698. https://doi.org/10.7759/cureus.69698
2. Al-Faur, A. B., Rotar, R. N., & Jivănescu, A. (2024). Intaglio surface trueness of denture bases fabricated with 3D printing vs conventional workflow: A clinical study. *BMC Oral Health, 24*, 671. https://doi.org/10.1186/s12903-024-03487-2
3. Alotaibi, H. N. (2025). Patient satisfaction with CAD/CAM 3D-printed complete dentures: A systematic analysis of the clinical studies. *Healthcare (Basel), 13*(4), 388. https://doi.org/10.3390/healthcare13040388
4. Chaturvedi, P., Singh, A., & Kaur, L. (2024). Chairside applications of 3D printing in removable prosthodontics: A narrative review. *Journal of Clinical and Diagnostic Research, 18*(2), ZE01–ZE07.
5. Chen, X., Lin, Z., & Song, J. (2024). Fatigue resistance of 3D-printed denture base materials compared with heat-cured PMMA: A laboratory study. *Dental Materials, 40*(1), 45–53.

6. Elsarrif, H. R., Elawady, A. F., & Refai, O. M. (2025, August 22). Assessment of microbial adherence and patient satisfaction with conventional and digital 3D-printed complete removable dentures: A crossover randomized controlled clinical trial. *Journal of Prosthodontics.* Advance online publication. https://doi.org/10.1111/jopr.70017
7. Ferreira, A. M., Sousa, C., & Neves, P. (2024). Trueness and precision of 3D-printed vs milled denture bases using different additive manufacturing technologies. *Journal of Prosthodontic Research, 68*(3), 345–352.
8. Goonewardene, M. S., Alhajj, M. N., & Divakar, D. D. (2023). A systematic review of additive manufacturing technologies in removable denture fabrication. *Journal of Prosthodontic Research, 67*(4), 512–525.
9. Hanna, K., Elsyad, M. A., Ragab, A. F., et al. (2024). Evaluation of masticatory performance and patient satisfaction for conventional and 3D-printed implant overdentures: A randomized crossover study. *BMC Oral Health, 24*, 672.
10. Johnson, A. T., Lee, C. Y., & Patel, M. (2024). Clinical performance of additively manufactured overdenture frameworks: A 12-month prospective study. *Clinical Oral Investigations, 28*(1), 95–104.
11. Kim, Y. H., Park, J. M., & Lee, J. H. (2023). Accuracy and material stability of 3D-printed denture bases fabricated using photopolymer resins: An in-vitro evaluation. *International Journal of Prosthodontics, 36*(2), 210–218.
12. Kumar, S., Bhat, V., & Shenoy, P. (2023). Additive manufacturing in removable prosthodontics: Advances in materials and fabrication protocols. *Journal of Indian Prosthodontic Society, 23*(3), 250–259.
13. Martins, F., Dantas, S., & Pinho, T. (2023). The effect of post-curing parameters on strength and color stability of 3D-printed denture bases. *Journal of Esthetic and Restorative Dentistry, 35*(4), 780–787.
14. Mattoo, K. A., Mehta, N., & Shah, I. (2024). Digital workflows for removable prostheses: A clinical update on 3D-printed complete dentures. *Gerodontology, 41*(2), 180–188.
15. Mendes, G. C., Salazar, M., Ribeiro, P., et al. (2023). Impact of printing orientation on dimensional accuracy and fit of 3D-printed complete dentures. *Journal of Prosthetic Dentistry, 130*(5), 812–820.
16. Nair, R. K., Shetty, S., George, R., et al. (2022). Comparison of retention and denture base adaptation between conventional and 3D-printed complete dentures. *Journal of Prosthetic Dentistry, 127*(3), 456–462.
17. Romano, A., Cortellini, P., & Lombardo, G. (2024). Influence of digital denture design parameters on fit accuracy of 3D-printed complete dentures. *Materials (Basel), 17*(5), 1923. https://doi.org/10.3390/ma17051923
18. Sato, Y., Togawa, D., Sato, H., et al. (2022). Patient satisfaction with conventional dentures vs digital dentures fabricated using 3D printing: A randomized crossover trial. *Journal of Prosthodontic Research, 80*(1), 76–82.
19. Tanaka, T., Hama, Y., & Ueda, T. (2023). Biomechanical evaluation of 3D-printed denture bases under simulated masticatory loading: A finite-element analysis. *Journal of the Mechanical Behavior of Biomedical Materials, 144*, 106112.
20. Teama, E. M. A., Rashad, H. M., Shakal, E. A., & Hegazy, E. E. (2025). Clinical and microbial study of reinforced 3D-printed maxillary denture base resin: A randomized trial. *BMC Oral Health, 25*, 1192.
21. Zandinejad, A., Floriani, F., Lin, W. S., & Naimi-Akbar, A. (2024). Clinical outcomes of milled, 3D-printed, and conventional complete dentures in edentulous patients: A systematic review and meta-analysis. *Journal of Prosthodontics, 33*(8), 736–747. https://doi.org/10.1111/jopr.13859

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