



## Post-Curing Duration on the Mechanical Performance and Surface Quality of LCD-Printed Denture Base Resin

Nooralhoda Saadallah Alhamdani, Ahmed Asim Al-Ali

*College of Dentistry, University of Mosul, Iraq*

### Abstract

**Objective:** To investigate how post-curing times of 10 minutes and 20 minutes affect the mechanical properties and surface characteristics of LCD-printed denture base resin. **Materials and Methods:** Ninety standardized specimens were fabricated and distributed across three experimental groups consisting of an untreated control sample and two groups that received post-curing treatments for 10 minutes and 20 minutes. The three-point bending test evaluated flexural strength through its testing procedure. Vickers microhardness testing in a microhardness indenter was used to measure hardness while digital profilometry assessed surface roughness. **Results:** A trend for improved mechanical properties was observed with extended post-curing time although not statistically different. **Conclusion:** The mechanical strength of 3D-printed denture base resins may increase with longer post-curing times, but this method prevents damage to the surface.

### Open Access

Citation: Alhamdani NS, et al. (2026) Post-Curing Duration on the Mechanical Performance and Surface Quality of LCD-Printed Denture Base Resin. Dentistry 3000. 1:a001 doi:10.5195/d3000.2026.1274  
Received: March 30, 2026  
Accepted: April 3, 2026  
Published: April 30, 2026  
Copyright: ©2026 Alhamdani NS et al. This is an open access article licensed under a Creative Commons Attribution Work 4.0 United States License.  
Email: nooralhoda.23dep1@student.uomosul.edu.iq

### Introduction

The curing time stands as the essential element which determines the success of post-polymerization elements. Research shows that longer post-curing periods lead to enhanced flexural strength and surface hardness and improved structural stability for 3D-printed denture base materials [1,2]. The extended curing process results in better cytocompatibility because it allows complete polymerization and removes all remaining monomers [3]. The scientific community has not established the best post-curing time because studies show that additional curing time beyond a certain point does not improve results, but data also indicate better results from longer exposure times [4,5]. The current knowledge about post-curing time effects on printed denture base resin

mechanical and surface properties remains unclear. The current work examined how two different post-curing times (10 minutes and 20 minutes) affect the mechanical properties and surface characteristics of LCD-printed denture base resin. We aimed to determine how different curing times affected material properties to determine the most effective curing method which will enhance 3D-printed denture base stability and patient outcomes. The aim of this study was to investigate how post-curing times of 10 minutes and 20 minutes impacted the flexural strength, Vickers microhardness, and surface roughness of 3D-printed denture base resin made through LCD technology. The study assessed critical mechanical and surface properties to verify if

longer post-polymerization times generated beneficial outcomes which support longer processing times.

The research hypothesis was that longer post-curing periods from 10 to 20 minutes will boost both flexural strength and Vickers microhardness of printed resin through better polymer cross-linking without causing substantial changes to surface roughness. The researchers based their hypothesis on previous studies which demonstrated that mechanical strength responds better to curing time than surface texture does.

### Materials and Methods

Post-curing time was studied as the independent variable to determine its effect on flexural

strength (FS), Vickers microhardness (VHN), and surface roughness (Ra) which were the dependent variables. We fabricated ninety standardized specimens which were divided into three experimental groups that included a control group without post-curing and two groups with 10-minute and 20-minute UV-curing times ( $n = 10$  per test per group). We followed ISO 1567 guidelines for all procedures to achieve both reproducibility and comparison with existing published research.

A 3D printer (Phrozen Sonic 4K from Phrozen Co., Taiwan) along with Senertek Denture Base Resin (Senertek Co., China) produced all specimens. The 405-nm wavelength light source operated at 50- $\mu\text{m}$  layer thickness to finish the printing operation. The flexural testing bar specimens measured 64 mm  $\times$  10 mm  $\times$  3.3 mm in size, but the disk-shaped specimens used for hardness and roughness analysis measured 25 mm  $\times$  25 mm  $\times$  3 mm.

The 0° build angle selection minimized anisotropic effects which allowed the printed layers to achieve full polymerization. The specimens needed 4 minutes of ethanol ultrasonic cleaning followed by 30 seconds of air drying to remove excess resin, particularly those printed at a 0° build angle, exhibited the least solubility and good water resistance compared to CAD/CAM and control PMMA groups [6].

The Formlabs UV-curing unit (Formlabs Inc., USA) with its 405-nm LED light source and temperature control system performed post-polymerization operations. Three curing methods were tested.

The control group received no post-curing treatment while the other two groups received 10 minutes and 20 minutes of UV exposure at 60°C. The selected curing parameters followed both the manufacturer's recommended settings and scientific data from previous research studies [7]. The specimens required 24 hours of room temperature storage at  $23 \pm 2$  °C to achieve structural stability and minimize internal stress before they underwent mechanical testing.

The universal testing machine conducted three-point bending tests based on ISO 1567 standards to determine flexural strength. The testing machine maintained a steady speed while the specimen rested on a metal support with established span length (L) until the material reached its failure point. The formula for calculating flexural strength (FS) includes the following variables:

$$FS = 3FL / (2bh^2)$$

The flexural strength (FS) measurement depends on four factors which include maximum load (N) and span length (mm) and width (mm) and specimen thickness (mm). The laboratory tests ran under controlled conditions with a

single trained operator to reduce human-related testing mistakes.

The digital microhardness tester Model HVS-1000 from Jinan Liangong China performed Vickers microhardness tests by applying 100-g force for 15 seconds. The testing area received three equally spaced indentations to avoid impression overlap between them. The 40 $\times$  optical microscope enabled automatic VHN value calculations through its measurement of indentation diagonals. The testing method produces exact results about surface quality and polymer structure development.

A digital profilometer (Mitutoyo SJ-210 from Japan) operated to measure surface roughness (Ra) based on ISO 4287 standards was used. The stylus conducted measurements on all test specimens through a 4-mm distance at 0.5 mm/s while applying 0.75 mN of force. The digital profilometer measured three different orientations of each specimen to calculate their final Ra value through arithmetic mean calculation [8].

The IBM SPSS Statistics version 26.0 software (IBM Corp. from the USA) processed all quantitative data. The results presented descriptive statistics through mean values and standard deviation (SD) measurements. The Shapiro-Wilk test confirmed the normal distribution of the data. The research used One-way ANOVA to identify differences between groups followed by Duncan's post-hoc test for detailed group comparisons after reaching statistical significance. The software GraphPad Prism 10 from GraphPad Software generated visual representations which displayed mean values with SD error bars and  $p < 0.05$  significance indicators for all comparisons at  $p < 0.01$  for highly significant results.

## Results

The printed specimens maintained their uniform shape and achieved proper surface finish without showing any signs of defects including delamination or voids or discoloration. The research results showed that flexural strength and Vickers microhardness values depended on post-curing time, but surface roughness remained unchanged between the different groups (Table 1).

**Table 1. Flexural strength (MPa) of 3D-printed denture base resin under different post-curing durations.**

Post-curing Duration	Mean (MPa)	SD
Control (No curing)	61.03	2.66
10 minutes	88.08	2.34
20 minutes	91.76	2.48

ANOVA:  $F(2,27) = p < 0.001$

The control group demonstrated the lowest flexural strength at 61.03 MPa because their printed state had not achieved complete polymerization. The flexural strength reached 88.08 MPa after ten minutes of post-curing but it reached its peak at 91.76 MPa when the curing time was extended to twenty minutes.

The research findings showed that groups demonstrated statistically significant differences ( $p < 0.001$ ) which proved that longer UV exposure creates more cross-links that lead to better bending resistance.

The Vickers microhardness values (Table 2) produced higher results when the post-curing time duration became longer. The control group showed the lowest hardness value at 9.17 VHN. The hardness value reached 16.98 VHN after ten minutes of curing but reached its peak at 17.86 VHN when curing lasted for twenty minutes. The analysis of variance (ANOVA) results demonstrated that these differences reached statistical significance ( $p < 0.001$ ) because microhardness shows strong sensitivity to UV-based polymerization methods.

**Table 2. Vickers microhardness (VHN) of 3D-printed denture base resin under different post-curing durations.**

Post-curing Duration	Mean (VHN)	SD
Control (No curing)	9.17	0.90
10 minutes	16.98	0.38
20 minutes	17.86	0.52

ANOVA:  $F(2,27) , p < 0.001$

The surface roughness measurements maintained clinical acceptable values between 0.15  $\mu\text{m}$  and 0.16  $\mu\text{m}$ . The surface roughness measurements between the control group and cured groups showed no statistically meaningful differences ( $p = 0.517$ ) as shown in Table 3.

**Table 3. Surface roughness (Ra,  $\mu\text{m}$ ) of 3D-printed denture base resin under different post-curing durations.**

Post-curing Duration	Mean (Ra, $\mu\text{m}$ )	SD
Control (No curing)	0.150	0.046
10 minutes	0.168	0.020
20 minutes	0.153	0.033

ANOVA:  $F(2,27) 0.78 = p = 0.517$  (ns)

## Discussion

The study evaluated the effects of two post-curing time intervals at 10 minutes and 20 minutes on the mechanical strength and surface finish of LCD-printed denture base resin.

The research results show that longer curing times lead to better flexural strength and Vickers microhardness results, but surface roughness stays unchanged regardless of curing time settings. The research confirms previous findings about photopolymer dental materials because extended UV exposure creates stronger polymer cross-links which results in better material consolidation.

The material flexural strength reached higher levels when researchers prolonged the post-curing time to 10 and 20 minutes. The polymer network development becomes more complete as the post-curing time extends. The green-state specimens showed the lowest strength of 61.03 MPa because their incomplete conversion happened due to oxygen inhibition and limited monomer movement during the first layer curing process. The research supports previous work which showed that longer post-curing times lead to better mechanical properties in printed resin materials [1].

The mechanical gains identified in this study come from generation and cross-linking during UV exposure. The incremental improvement, between 10 and 20 minutes confirms that polymer conversion continues after the plateau phase. The polymer conversion after the plateau phase strengthens the cohesion of the resin [3].

Flexural strength and microhardness increased when the post-curing time was longer. Flexural strength and microhardness do not directly confirm the degree of monomer conversion because the study did not perform conversion measurements. Including degree-of-conversion analysis in future studies would provide a more definitive explanation for the mechanical improvements observed.

The microhardness results tracked the flexural strength data by showing a major boost from the control group to the 10-minute and 20-minute curing groups. The surface polymerization starts responding right away to UV light because it increases from 9.17 VHN in the control group to 16.98 VHN after 10 minutes of exposure. The surface polymer layers achieve additional cross-linking during the 20-minute exposure period which results in a hardness value of 17.86 VHN.

The research findings from this study confirm the results which Al-Dulajjan et al. (2022) and Jeong et al. (2023) who demonstrated that longer exposure times lead to better monomer conversion which results in increased hardness values. The research findings provide useful applications because harder surfaces demonstrate enhanced resistance to wear and tear and improved structural integrity which leads to extended prosthesis service duration [9,10].

The surface roughness measurements showed no statistical difference between any of the tested groups. The Ra values showed a narrow range between 0.15–0.16  $\mu\text{m}$  while remaining under the 0.2  $\mu\text{m}$  threshold which medical staff use as their reference point. The microtopography of printed resin remains unchanged after post-curing because the surface morphology forms during the printing process.

The research results match previous studies [9,11] that demonstrated that surface roughness remained unchanged when the curing process extended beyond its typical duration. The research findings indicate that surface roughness emerges from print resolution and resin viscosity and layer thickness but does not relate to UV exposure during post-processing. The present research validates that 20-minute post-curing yields optimal mechanical properties for 3D-printed denture resins while maintaining surface smoothness which enhances patient comfort and bacterial resistance. Clinical denture base production needs research-backed curing protocols for 3D-printed dentures because they must achieve both durability and biocompatibility and stability.

### Conclusion

Post-curing time duration determines how LCD-printed denture base resin will behave mechanically. The material achieved better polymer conversion and structural consolidation when UV exposure reached twenty minutes instead of ten minutes which resulted in higher flexural strength and Vickers microhardness values. The surface roughness measurements showed no variation between different curing times because they stayed under the recommended clinical limit. The surface topography depends mainly on printing parameters instead of post-polymerization conditions because it remains stable throughout all testing periods.

The research findings demonstrated that a 20-minute post-curing process achieves the best results by strengthening the material while maintaining its surface finish. The development of evidence-based curing protocols for digital fabrication will improve workflow stability and ensure durable long-term performance of 3D-printed denture prostheses.

The research employed one LCD printer together with one denture base resin. The research findings have specific restrictions regarding their applicability to different printers and resin materials. The research study failed to measure two essential variables which included degree of conversion and polymer cross-linking density. The research findings about post-curing mechanisms depend on two

essential indicators which are degree of conversion and polymer cross-linking density. The research investigation excluded three essential factors which included build orientation and aging simulation and intraoral thermal cycling. The research study failed to evaluate how build orientation and aging simulation and intraoral thermal cycling affect long-term performance.

Future studies should investigate the effects of different curing durations on the material. Researchers should attempt to develop new resin formulations for their studies. Researchers should conduct experiments to evaluate different printing settings. Future research can gain better understanding of interactions through experiments that test extended curing periods and various resin types and multiple printing conditions. Future research should implement FTIR and SEM as their analytical methods. Future research needs to conduct both aging simulations and clinical trials. The research will obtain valuable information about polymer behavior through aging simulation and clinical trial experiments. The results from aging simulations and clinical trials will enable researchers to develop improved post-curing protocols for clinical use.

### References

1. Kim, D., Shim, J.-S., Lee, D., Shin, S.-H., Nam, N.-E., Park, K.-H., Shim, J.-S. and Kim, J.-E., 2020. Effects of post-curing time on the mechanical and color properties of three-dimensional printed crown and bridge materials. *Polymers*, 12(11), article 2762.
2. Bayarsaikhan, E., Lim, J.-H., Shin, S.-H., Park, K.-H., Park, Y.-B., Lee, J.-H. and Kim, J.-E., 2021. Effects of post-curing temperature on the mechanical properties and biocompatibility of three-dimensional printed dental resin material. *Polymers*, 13(8), article 1180.
3. Aati, S., Akram, Z., Shrestha, B., Patel, J., Shih, B., Shearston, K., Ngo, H. and Fawzy, A., 2022. Effect of post-curing light exposure time on the physico-mechanical properties and cytotoxicity of 3D-printed denture base material. *Dental Materials*, 38(1), pp.57–67.
4. Soto-Montero, J., de Castro, E.F., Romano, B.C., Nima, G., Shimokawa, C.A.K. and Giannini, M., 2022. Color alterations, flexural strength, and microhardness of 3D printed resins for provisional restorations using different post-curing times. *Dental Materials*, 38(8), pp.1271–1282.
5. AlRumaih, H.S. and Gad, M.M., 2024. The effect of 3D printing layer thickness and post-polymerization time on the flexural strength and hardness of denture base resins. *Prosthesis*, 6(4), pp.970–978.
6. Qasim, H. H., Abdulla, M. A., & Mohialdeen, H. K. (2026). Water Sorption and Solubility Behavior of Provisional Restorative Materials Fabricated by Conventional, CAD/CAM, and 3D

- printing Methods. *Al-Rafidain Dental Journal*, 26(1), 38–57.
7. 7. Chen, H., Cheng, D.-H., Huang, S.-C. and Lin, Y.-M., 2021. Comparison of flexural properties and cytotoxicity of interim materials printed from mono-LCD and DLP 3D printers. *Journal of Prosthetic Dentistry*, 126(5), pp.703–708.
  8. 8. Lee, E.-H., Ahn, J.-S., Lim, Y.-J., Kwon, H.-B. and Kim, M.-J., 2022. Effect of post-curing time on the color stability and related properties of a tooth-colored 3D-printed resin material. *Journal of the Mechanical Behavior of Biomedical Materials*, 126, article 104993.
  9. 9. Al-Dulaijan, Y.A., Alsulaimi, L., Alotaibi, R., Alboainain, A., Alalawi, H., Alshehri, S., Khan, S.Q., Alsaloum, M., AlRumaih, H.S., Alhumaiddan, A.A. and Gad, M.M., 2022. Comparative evaluation of surface roughness and hardness of 3D printed resins. *Materials*, 15(19), article 6822.
  10. 10. Jeong, M., Radomski, K., Lopez, D., Liu, J.T., Lee, J.D. and Lee, S.J., 2023. Materials and applications of 3D printing technology in dentistry: An overview. *Dentistry Journal*, 12(1), article 1.
  11. 11. Li, P., Lambart, A.-L., Stawarczyk, B., Reymus, M. and Spintzyk, S., 2021. Postpolymerization of a 3D-printed denture base polymer: Impact of post-curing methods on surface characteristics, flexural strength, and cytotoxicity. *Journal of Dentistry*, 115, article 103856.