ORIGINAL ARTICLE

Revolution in Provisional Restoration: Meet the New Generation of Materials

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Abstract

Objectives: The provisional or interim phase represents an important aspect of restorative treatment. It serves as a crucial tool for assessing whether the tooth preparation is sufficient for a definitive prosthesis. A provisional restoration can be either prefabricated or custom-made, and a wide variety of materials can be used. Fabrication technologies include subtractive (milling), additive (three-dimensional [3D] printing), and conventional (using self-cured materials) techniques. This study aimed to evaluate the flexural strength of three different types of provisional restorative materials after simulation of oral conditions using a thermocycling protocol. **Materials and Methods:** Three provisional restorative materials were evaluated for flexural strength after thermocycling; Pre-polymerized computer-aided design (CAD) and manufacturing resin block (VITA, computer-aided design temporary [CAD-Temp]), 3D-printed resin (NextDent, Crown and Bridge micro filled hybrid [C&B MFH]), and Auto-polymerized polymethyl methacrylate (GC, Unifast III). 30 bar-shaped (25 × 2 × 2 mm ±0.1 mm) specimens were prepared from each resin material. Specimens of each material were divided into three groups (n = 10/group): Baseline (BL), 10,000, and 20,000 thermocycles. Flexural strength was determined using a three-point bending test performed with a universal testing machine. Statistical analysis was performed by two-way analysis of variance with Tukey-Kramer Honestly Significant Difference multiple comparison tests at $\alpha = 0.05$ significance level. **Results:** The flexural strength of all tested materials significantly decreased after thermocycling ($P < 0.05$). At BL, the milled CAD-Temp exhibited the highest flexural strength (102.51 MPa), followed by the 3D-printed C&B MFH (73.96 MPa) and the self-cured Unifast III (63.90 MPa). After 10,000 thermocycles, all materials showed a significant reduction in flexural strength, which further declined after 20,000 thermocycles. Despite aging, CAD-Temp maintained the highest flexural strength at both 10,000 and 20,000 thermocycles (80.48 and 70.77 MPa, respectively), while Unifast III consistently exhibited the lowest. Significant differences were observed among all materials within each thermocycling interval ($P < 0.05$). **Conclusion:** Thermocycling significantly reduced the flexural strength of all tested provisional materials. Milled CAD-Temp showed the highest flexural strength across all intervals, while 3D-printed C&B MFH demonstrated moderate strength. Unifast III consistently exhibited significantly lower flexural strength across the study.

Key words: Flexural strength, mechanical properties, milled materials, provisional restorations, three-dimensional-printed material

INTRODUCTION

Provisional restorations are temporary replacements that cover and protect prepared teeth before receiving the definitive restoration.[1] They play a crucial role in evaluating the tooth preparation parameters, including parallelism, proximal contacts, vertical dimension of occlusion, occlusal scheme, interocclusal distance, and pulp protection, ultimately improving periodontal health and patient satisfaction.[2] Provisional restorations can be categorized according to their intended duration of use into short-term (≤2 weeks)or long-term (>2 weeks to several months),[3] depending on the clinical need, such as stabilization before orthodontic treatment or periodontal and implant procedures.[4]

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Fabrication methods are divided into prefabricated and custom-made provisional restorations. Prefabricated crowns, available in polycarbonate or acrylic shells for anterior teeth and metal shells for posterior teeth, provide immediate chairside placement; however, they often require relining and occlusal adjustments for a precise fit.[5] Acrylic resins are typically used for relining to improve marginal adaptation. These restorations are limited to single-tooth applications due to the polymerization properties of self-cure resins.[3] Conversely, custom-made provisional restorations, fabricated either directly or indirectly, provide superior biological, functional, and aesthetic outcomes.

Conventionally, provisional restorations were fabricated using auto-polymerizing acrylic resins, most commonly polymethyl methacrylate (PMMA). Unifast III is a self-curing resin widely used owing to its strength, high wear resistance, ease of adjustment, and satisfactory aesthetics. However, polymerization shrinkage, porosity, heat generation from exothermic reaction during setting, and pulpal or gingival irritation due to residual monomer release limit its application in long-term applications.[5,6]

The evolution of computer-aided design and manufacturing (CAD/CAM) technologies, including subtractive (milling) and additive (three-dimensional [3D] printing)manufacturing techniques, has improved the fabrication of indirect provisional restorations by overcoming several inherent limitations of conventional fabrication techniques.[7,8] CAD/CAM systems integrate digital scanning, software design, and automated fabrication to achieve higher precision, reduced fabrication time, and enhanced reproducibility.[9,10] Milled restorations fabricated from pre-polymerized resin blocks eliminate polymerization shrinkage and minimize residual monomer release.[11,12] A representative example is VITA computer-aided design temporary (CAD-Temp), a high-molecular-weight cross-linked acrylate polymer reinforced with micro-particle fillers, which exhibits well-balanced mechanical properties.[13,14]

3D printing has further expanded the scope of provisional restoration fabrication, allowing the production of more complex geometries with reduced material waste.[15] NextDent Crown and Bridge micro-filled hybrid (C&B MFH), a 3D-printed micro-filled hybrid resin indicated for long-term temporary restorations, as claimed by the manufacturer, which reports an acceptable flexural strength.[16] Compared with conventional self-cured resins, vat-photopolymerization technique of 3D printing minimizes operator-dependent mixing defects and allows for more consistent polymerization; however, the layer-by-layer process may still introduce structural discontinuities.[17] Post-processing procedures, including removal of the support structure, washing of unpolymerized monomer, and post-curing, remain critical to ensure optimized mechanical properties, biocompatibility, durability, accuracy, and aesthetics.[18] Comparative studies evaluating the mechanical properties of additive and subtractive techniques have shown that 3D-printed restorations generally exhibit reduced flexural strength, Vickers microhardness, Martens hardness, and elastic modulus compared with milled counterparts.[17]

Although provisional materials are not designed to match the durability of definitive restorations, maintaining sufficient mechanical properties during function is critical.[19] Among these, flexural strength serves as a key mechanical indicator, reflecting a material's resistance to deformation under bending forces.[20] Dental restorations are exposed to challenging factors in the oral cavity; however, only a limited number of *in vitro* studies have evaluated the effect of artificial aging on the flexural strength.[21] Thermocycling, with hot and cold water, typically between 5°C and 55°C, is one of the approved methods that simulates the thermal stress in the oral environment.[22] Given the advancements in fabrication techniques and materials, evaluating the durability of digitally manufactured provisional restorations is essential.

Aim of the study

The aim of the study was to evaluate the effect of thermocycling on the flexural strength of three provisional restorative materials: Pre-polymerized CAD/CAM resin block (CAD-Temp, VITA Zahnfabrik, Germany), 3D-printed resin (NextDent C&B MFH, 3D systems, The Netherlands), and Auto-polymerized PMMA (Unifast III, GC, Japan).

MATERIALS AND METHODS

Three resin materials indicated for provisional restoration were evaluated: Pre-polymerized CAD/CAM resin block (VITA, CAD-Temp), 3D-printed resin (NextDent, C&B MFH), and Auto-polymerized PMMA (GC, Unifast III) [Table 1].

Study design

The sample size was calculated using G*Power software V3.1.3 (Heinrich Heine University, Germany) for two-way analysis of variance (ANOVA). 30 specimens per material provided 80% powerat $\alpha = 0.05$.

Specimens from each material were randomly allocated into three groups corresponding to the aging conditions: Baseline (BL), 10,000 thermocycles, and 20,000 thermocycles. Flexural strength was measured after immersion of specimens in distilled water at 37°C for 24 h as BL, and following each thermocycling interval [Figure 1].

Specimens preparation

30 bar-shaped (25 × 2 × 2 mm ± 0.1 mm) specimens were prepared from each provisional resin material as follows

Table 1: Specimens preparation

Material	Manufacturing technique	Composition	Weight %	Manufacturer
Unifast III	Conventional	• Methyl methacrylate • N, N-dimethyl-p-toluidine • Ethylene glycol dimethacrylate • Propylidynetrimethyl trimethacrylate • 2-(2H-benzotriazol-2-yl)-p-cresol • Butylated hydroxytoluene • titanium dioxide	90–<100 2.5-<5 1–<2.5 1–<2.5 ≥0.25–<0.5 0.1–<0.2% 0.5–<1%	GC
C&B MFH	3D printing	• 7,7,9 (or 7,9,9)-trimethyl–4,13-dioxo–3,14-dioxa–5,12-diazahexadecane –1,16-diyl bismethacrylate • 2-hydroxyethyl methacrylate Ethoxylated bisphenol A dimethacrylate • Ethylene dimethacrylate • Silicon dioxide • Diphenyl (2,4,6-trimethylbenzoyl) phosphine oxide • Mequinol; 4-methoxyphenol; hydroquinone monomethyl ether • Titanium dioxide	50–75 <25 <10 <10 1–5 1–5 <0.1 <0.1	3D systems
CAD-temp	Milling	• Poly-methyl methacrylate • Silicon dioxide • Pigments	83–86 14 <0.1	VITA Zahnfabrik

C&B MFH: Crown and Bridge micro filled hybrid, CAD-temp: Computer-aided design temporary

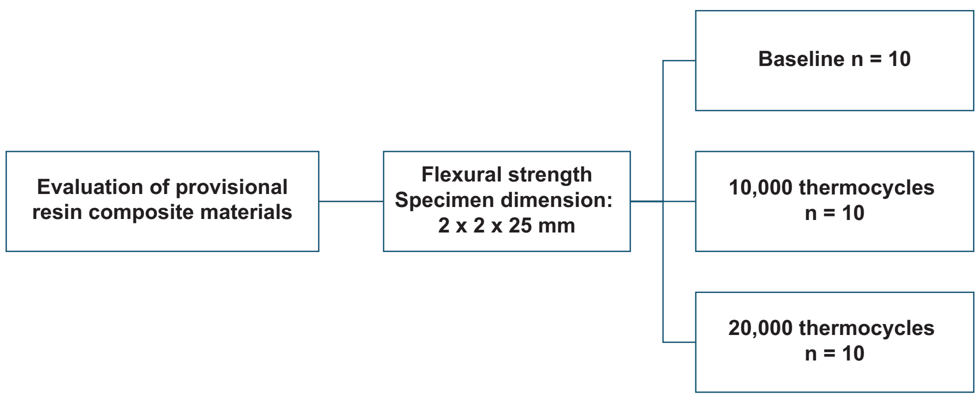

Figure 1: Study design

[Table 1]: 3D-printed specimens were digitally designed as Standard Tessellation Language, and printed using Asiga MAX 3D printer (Asiga, Sydney, Australia), employing digital light processing technology. Support structures were carefully removed, and specimens were washed, post-polymerized, finished, and polished according to the manufacturer's recommendation. Specimens of the pre-polymerized resin blocks were sectioned using a low-speed water-cooled Isomet 1000 Precision Saw (Buehler Co, IL, USA). The self-cured resin specimens were mixed and adapted into a stainless-steel mold of the specified dimensions. A digital micrometer was used to control the dimensions of each specimen to an accuracy of 0.01 mm to ensure standardization.

Flexural strength

Flexural strength of each group ($n = 10$) was measured by three-point bending test using a universal testing machine (InstronElectroPuls E1000, Norwood, MA, USA). Each specimen was placed on supports spaced 20 mm apart and loaded at the top center at a crosshead speed of 1 mm/min until fracture. Flexural strength was calculated using the following equation:[23]

$$\sigma = \frac{3FL}{2bh^2}$$

Where F is the maximum applied load (N), L is the support span (20 mm), b is the width of the specimen (mm), and h is the height of the specimen (mm).

Thermocycling process

Thermocycling was performed using a thermocycler (SD Mechatronik, Germany) with distilled water as the medium. Each cycle consisted of 30 s in a 5°C bath, a 10 s transfer, 30 s in a 55°C bath, followed by a 10 s transfer back to the cold bath. For each material, one group (n = 10) was subjected to 10,000 thermocycles, and another group (n = 10) was subjected to 20,000 thermocycles [Figure 2].

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) software (IBM SPSS Statistics, Version 31; IBMCorp), and means and standard deviations were calculated. Two-way ANOVA with Tukey-Kramer Honestly Significant Difference multiple comparison test was performed to evaluate the effects of material type and aging on the flexural strength at α = 0.05 significance level.

RESULTS

Flexural strength mean values of the three provisional materials, Unifast III (self-cured), C&B MFH (3D-printed), and CAD-Temp (milled), at BL, after 10,000, and after 20,000 thermocycles are presented in Table 2 and illustrated in Figure 3.

At BL, CAD-Temp demonstrated the highest flexural strength (102.51 MPa), followed by C&B MFH (73.96 MPa) and Unifast III (63.90 MPa). After 10,000 thermocycles, a statistically significant decrease in flexural strength was observed in all materials (P < 0.05). The mean values for CAD-Temp, C&B MFH, and Unifast III declined to 80.48, 68.37, and 54.49 MPa, respectively.

Table 2: Flexural strength of the provisional restoration materials at BL, after 10,000 and 20,000 thermocycles in MPa

Thermocycle intervals	Flexural strength (MPa) Mean (±SD)		
	Unifast III	C&B MFH	CAD-temp
BL (0)	63.90^{Ca} (±2.20)	73.96^{Ba} (±3.90)	102.51^{Aa} (±2.93)
10,000	54.49^{Cb} (±2.30)	68.37^{Bb} (±3.01)	80.48^{Ab} (±2.35)
20,000	51.38^{Cb} (±4.06)	66.30^{Bb} (±4.86)	70.77^{Ac} (±1.70)

In each column, different lowercase superscript letters indicate a significant difference between flexural strength at different thermocycle intervals (0 (BL), 10,000, and 20,000 thermocycles), within each material (P<0.05). In each row, different uppercase superscript letters indicate a significant difference between the flexural strength of different materials within the same thermocycles interval (P<0.05). BL: Base line, SD: Standard deviation, C&B MFH: Crown and Bridge micro filled hybrid, CAD-temp: Computer-aided design temporary

Further significant reduction in flexural strength was observed across all groups after 20,000 thermocycles (P < 0.05). CAD-Temp showed the highest flexural strength (70.77 MPa) among other materials; in contrast, Unifast III exhibited the lowest (51.38 MPa). C&B MFH demonstrated an intermediate value of 66.30 MPa [Figure 4].

Moreover, comparisons among the materials throughout the study revealed statistically significant differences (P < 0.05). Milled CAD-Temp consistently demonstrated the highest flexural strength, followed by 3D-printed C&B MFH, whereas self-cured Unifast III presented the lowest values.

DISCUSSION

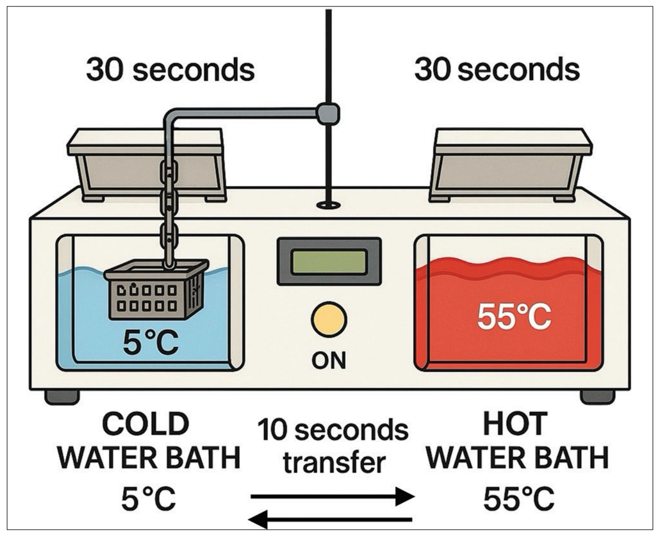

Figure 2: Thermocycling process

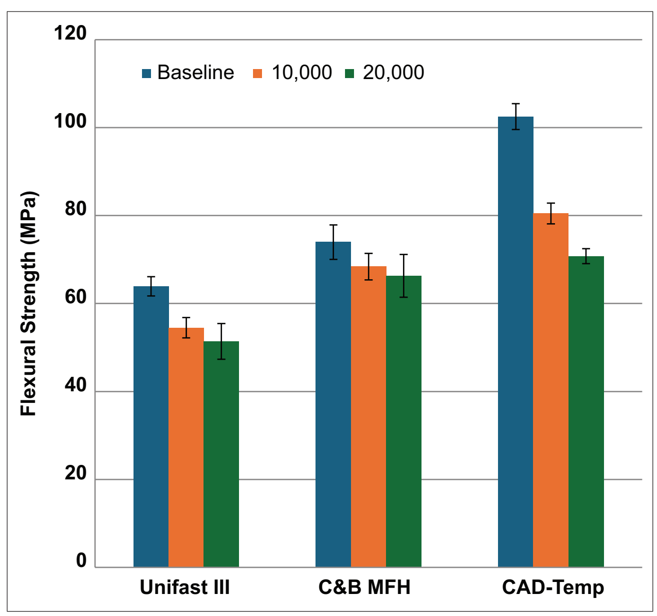

Figure 3: Impact of thermocycling on the provisional materials' flexural strength

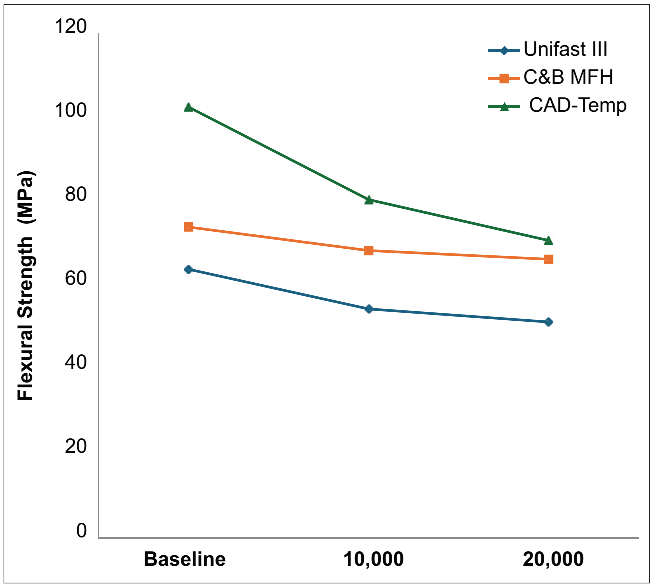

Figure 4: Trend of flexural strength reduction after thermocycling for the provisional materials

Flexural strength is a combination of tensile and compressive stresses. It is a critical mechanical property for provisional restoration, as the latter should withstand mastication forces in the oral cavity during the interim phase.[17,20,24] This study assessed the new generation of provisional restorations to explore the new opportunities for the future of dentistry. Flexural strength of three provisional materials, representing different manufacturing techniques: milled PMMA-based resin block (CAD-Temp), 3D-printed resin (C&B MFH), and self-cured acrylic resin (Unifast III), was evaluated at BL and after artificial aging by thermocycling. Measurements were performed at BL, after 10,000 (mimicking 12 months of clinical use), and 20,000 thermocycles (mimicking 24 months of clinical use).[25-27]

At BL, CAD-Temp exhibited the highest flexural strength (102.51 MPa), which aligns with previous reports indicating that milled resin blocks offer superior mechanical properties compared with 3D-printed materials,[28-30] and auto-polymerized acrylic resin.[31] This could be attributed to the controlled polymerization that produces more homogenous structures, with low residual monomer and reduced porosity.[32,33] The intermediate BL strength of the 3D-printed C&B MFH (73.96 MPa) reflects its hybrid dimethacrylate-based composition and moderate filler content. The presence of highly crosslinked dimethacrylates and inorganic fillers supports higher rigidity and strength than self-cured PMMA. However, the layer-by-layer fabrication nature of the 3D printing can introduce interlayer defects and anisotropy, which may limit flexural performance relative to pre-polymerized milled blocks.[16,17,34] The significantly lower ($P < 0.0001$) flexural strength of Unifast III (63.90) is consistent with previous findings regarding the limitation of the auto-polymerized PMMA systems, where lower polymerization temperature, increased porosity, and shorter molecular chains lead to inferior mechanical performance.[35] In contrast, digitally fabricated materials generally achieve a higher degree of conversion, leading to superior flexural strength.[36-38]

Thermocycling induced a significant decrease in the flexural strength of all groups ($P < 0.0001$), a result consistent with previous studies that reported similar post-thermocycling reduction in flexural strength of resin composites.[31,39] This deterioration can be attributed to the material degradation resulting from temperature fluctuations and water sorption/desorption cycles inherent to the thermocycling process. Temperature fluctuations cause repeated thermal expansion and contraction within the polymer network, generating internal stresses and accelerating fatigue at the molecular level, affecting interchain interactions and the filler/matrix interface.[14,40] Simultaneously, immersion in water during thermocycling permits water molecules to diffuse into the polymer matrix following Fickian kinetics, leading to plasticization of the organic phase, reduction in intermolecular forces, dimensional changes within the network, and potential hydrolysis at susceptible sites, collectively weakening the structural stability and adversely affecting the material properties.[19,41-45]

After 20,000 thermocycles, simulating approximately 24 months of clinical service,[25-27] the flexural strength of CAD-Temp, C&B MFH, and Unifast III significantly decreased to 70.77, 66.30, and 51.38 MPa, respectively ($P < 0.0001$). Although CAD-Temp maintained the highest absolute values at each interval, it also showed the largest relative loss in flexural strength (approximately 30% reduction from BL), whereas C&B MFH demonstrated a more moderate decline (≈10%), and Unifast III showed an intermediate decrease (≈20%).

The variation in the degree of degradation among materials is influenced by their chemical composition and manufacturing method.[41] CAD-Temp consists of a PMMA-based matrix reinforced with 14 wt% SiO_2 fillers. While the inorganic filler phase contributes to higher strength, the filler/matrix interface represents critical sites for water penetration and thermally induced stress, making them susceptible to debonding and microcrack propagation.[46]

The 3D-printed C&B MFH exhibited a lower reduction in flexural strength following thermocycling compared to milled CAD-Temp. The enhanced stability could be partially attributed to its post-polymerization curing protocol, which increases the degree of conversion, reduces residual monomer content, and limits water absorption,[47] thereby enhancing mechanical resilience.[36-38]

For Unifast III, its chemically activated mechanism and PMMA-based composition account for both its lower initial strength and its susceptibility to aging.[46,48] The material relies on room-temperature polymerization of methyl methacrylate with tertiary amine accelerator (N,N-dimethyl-p-toluidine) and cross-linking monomers (e.g., ethylene glycol dimethacrylate). Such conditions typically result in a lower degree of conversion, higher residual monomer, and greater internal porosity than those achieved in industrial or light-cured systems.[35,46]

Limitations

Despite the insights gained into the new generation of temporary restorations, this study has some limitations. Thermocycling cannot fully replicate the complexity of the oral environment or the multiple aging factors that affect treatment success, including masticatory forces, erosive effects of pH changes, and biological factors present in the oral cavity. Another limitation is the standardized shape and thickness of all specimens, which do not replicate the geometric complexity and thickness variations of clinical restorations, such as a crown.

CONCLUSION

Thermocycling significantly reduced the flexural strength of all tested provisional materials. Milled CAD-Temp showed the highest flexural strength across all intervals, while 3D-printed C&B MFH demonstrated moderate strength. Unifast III consistently exhibited significantly lower flexural strength across the study.

Future recommendations

Future research should include clinical trials to validate *in vitro* findings. Investigations should also assess other mechanical properties, such as wear resistance and fracture toughness. Furthermore, studies evaluating multilayer and hybrid fabrication techniques, as well as optimization of post-processing protocols for 3D-printed resin, may provide insights for improving the mechanical performance and clinical stability of provisional restorations.

ETHICAL APPROVAL

Ethical approval was exempted by the Institutional Review Board of King Abdulaziz University, as the study was conducted as an *in vitro* experiment.

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DATA AND MATERIALS AVAILABILITY

All data associated with this study are presented within the paper. This study followed EQUATOR guidelines for *in vitro* research.

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REFERENCES

1. Schwantz JK, Oliveira-Ogliari A, Meereis CT, Leal FB, Ogliari FA, Moraes RR. Characterization of bis-acryl composite resins for provisional restorations. Braz Dent J 2017;28:354-61.
2. Alsaggaf AU. Introduction of dental provisional materials used in prosthodontics. Mod Res Dent 2019;4:418-9.
3. Gandhimathi J, Kanmani M, Nasreen S, Vinayagavel K, Sabarigirinathan C, Srinidhi L. Recent advances in provisional restorations. IOSR J Dent Med Sci 2019;18:53-8.
4. Spear F. An interdisciplinary approach to the use of long-term temporary restorations. J Am Dent Assoc 2009;140:1418-24.
5. Burns DR, Beck DA, Nelson SK, Committee on Research in Fixed Prosthodontics of the Academy of Fixed Prosthodontics. A review of selected dental literature on contemporary provisional fixed prosthodontic treatment: Report of the committee on research in fixed prosthodontics of the academy of fixed prosthodontics. J Prosthet Dent 2003;90:474-97.
6. Tom TN, Uthappa MA, Sunny K, Begum F, Nautiyal M, Tamore S. Provisional restorations: An overview of materials used. J Adv Clin Res Insights 2016;3:212-4.
7. Miyazaki T, Hotta Y. CAD/CAM systems available for the fabrication of crown and bridge restorations. Aust Dent J 2011;56 Suppl 1:97-106.
8. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: An overview of recent developments for CAD/CAM generated restorations. Br Dent J 2008;204:505-11.
9. Birnbaum NS, Aaronson HB. Dental impressions using 3D digital scanners: Virtual becomes reality. Compend Contin Educ Dent 2008;29:494, 496, 498-505.
10. Mörmann WH, Brandestini M, Lutz F, Barbakow F. Chairside computer-aided direct ceramic inlays. Quintessence Int 1989;20:329-39.
11. AlRashdi AK, Mutairi FM, Aldubaikhi AH, Zaylaee LY, Alharbi AD, Mossa HM. Dental CAD/CAM: A brief review. Int J Med Dev Ctries 2020;4:1975-9.
12. Başak SS, Özmen MF, Sağsöz Ö, Bayindir F. Effect

of thermo-cycling on microhardness of CAD-CAM provisional materials. Int J Appl Dent Sci 2020;6:254-7.
13. Sayegh SM, Daou M, Najjar G, Zebouni E. In vitro comparison of the color degradation of two computer-aided design/computer-aided manufacturing provisional materials: A 12-month simulation. J Indian Prosthodont Soc 2023;23:38-44.
14. Atay A, Sağirkaya E. Effects of different storage conditions on mechanical properties of CAD/CAM restorative materials. ODOVTOS Int J Dent Sci 2020;22:83-96.
15. Li X, Xie B, Jin J, Chai Y, Chen Y. 3D printing temporary crown and bridge by temperature controlled mask image projection stereolithography. Procedia Manuf 2018;26:1023-33.
16. Mudhaffer S, Haider J, Satterthwaite J, Silikas N. Effects of print orientation and artificial aging on the flexural strength and flexural modulus of 3D printed restorative resin materials. J Prosthet Dent 2025;133:1345-57.
17. Jain S, Sayed ME, Shetty M, Alqahtani SM, Al Wadei MH, Gupta SG, *et al*. Physical and mechanical properties of 3D-printed provisional crowns and fixed dental prosthesis resins compared to CAD/CAM milled and conventional provisional resins: A systematic review and meta-analysis. Polymers (Basel) 2022;14:2691.
18. Hassanpour M, Narongdej P, Alterman N, Moghtadernejad S, Barjasteh E. Effects of post-processing parameters on 3D-printed dental appliances: A review. Polymers (Basel) 2024;16:2795.
19. Romil S, Kumar AS, Kumar AS, Saurabh G, Praveen G, Siddhi T. An evaluation of flexural strength of different provisional restorative materials: An in-vitro study. Indian J Dent Sci 2012;4:17-9.
20. Sakaguchi RL, Powers JM. Restorative materials-composites and polymers. In: Craig's Restorative Dental Materials. 13th ed. Netherlands: Elsevier Health Sciences; 2012. p. 135-70.
21. Kadiyala KK, Badisa MK, Anne G, Anche SC, Chiramana S, Muvva SB, *et al*. Evaluation of flexural strength of thermocycled interim resin materials used in prosthetic rehabilitation- an in-vitro study. J Clin Diagn Res 2016;10:C91-5.
22. Kiomarsi N, Saburian P, Chiniforush N, Karazifard MJ, Hashemikamangar SS. Effect of thermocycling and surface treatment on repair bond strength of composite. J Clin Exp Dent 2017;9:e945-51.
23. International Organization for Standardization. ISO 4049:2019. Dentistry-Polymer-Based Restorative Materials. United States: ResearchGate; 2019.
24. Ellakany P, A Al-Dulaijan Y, M Aly N, Alshehri T, T Alameer S, Akhtar S, *et al*. Effect of thermocycling on flexural strength of dental CAD/CAM ceramics of variable thicknesses and structures: An in vitro study. F1000Res 2024;13:1310.
25. Çakmak G, Yilmaz H, Aydoğ Ö, Yilmaz B. Flexural strength of CAD-CAM and conventional interim resin materials with a surface sealant. J Prosthet Dent 2020;124:e800-7.
26. Alp G, Murat S, Yilmaz B. Comparison of flexural strength of different CAD/CAM PMMA-based polymers. J Prosthodont 2019;28:e491-5.
27. Debye K, Tuna T, Bishti S, Wolfart S. Influence of additional reinforcement of fixed long-term temporary restorations on fracture load. J Prosthodont Res 2018;62:416-21.
28. Grzebieluch W, Kowalewski P, Grygier D, Rutkowska-Gorczyca M, Kozakiewicz M, Jurczyszyn K. Printable and machinable dental restorative composites for CAD/CAM application-comparison of mechanical properties, fractographic, texture and fractal dimension analysis. Materials (Basel) 2021;14:4919.
29. Temizci T, Bozoğulları HN. Effect of thermocycling on the mechanical properties of permanent composite-based CAD-CAM restorative materials produced by additive and subtractive manufacturing techniques. BMC Oral Health 2024;24:334.
30. Prause E, Malgaj T, Kocjan A, Beuer F, Hey J, Jevnikar P, *et al*. Mechanical properties of 3D-printed and milled composite resins for definitive restorations: An in vitro comparison of initial strength and fatigue behavior. J Esthet Restor Dent 2024;36:391-401.
31. Yao J, Li J, Wang Y, Huang H. Comparison of the flexural strength and marginal accuracy of traditional and CAD/CAM interim materials before and after thermal cycling. J Prosthet Dent 2014;112:649-57.
32. Leung BT, Tsoi JK, Matinlinna JP, Pow EH. Comparison of mechanical properties of three machinable ceramics with an experimental fluorophlogopite glass ceramic. J Prosthet Dent 2015;114:440-6.
33. Goujat A, Abouelleil H, Colon P, Jeannin C, Pradelle N, Seux D, *et al*. Mechanical properties and internal fit of 4 CAD-CAM block materials. J Prosthet Dent 2018;119:384-9.
34. Zohdi N, Yang R. Material anisotropy in additively manufactured polymers and polymer composites: A review. Polymers (Basel) 2021;13:3368.
35. Zafar MS. Prosthodontic applications of polymethyl methacrylate (PMMA): An update. Polymers (Basel) 2020;12:2299.
36. Mayinger F, Reymus M, Liebermann A, Richter M, Kubryk P, Großekappenberg H, *et al*. Impact of polymerization and storage on the degree of conversion and mechanical properties of veneering resin composites. Dent Mater J 2021;40:487-97.
37. Calheiros FC, Daronch M, Rueggeberg FA, Braga RR. Degree of conversion and mechanical properties of a BisGMA: TEGDMA composite as a function of the applied radiant exposure. J Biomed Mater Res B Appl Biomater 2008;84:503-9.
38. Peutzfeldt A. Resin composites in dentistry: The monomer systems. Eur J Oral Sci 1997;105:97-116.
39. Janda R, Roulet JF, Latta M, Rüttermann S. The effects of thermocycling on the flexural strength and flexural modulus of modern resin-based filling materials. Dent

Mater 2006;22:1103-8.
40. Pieniak D, Niewczas A, Walczak A, Łępicka M, Grądzka-Dahlke M, Maciejewski R, *et al*. The effect of thermal stresses on the functional properties of various dental composites. Tribol Int 2020;152:106509.
41. El-Rashidy AA, Shaalan O, Abdelraouf RM, Habib NA. Effect of immersion and thermocycling in different beverages on the surface roughness of single- and multi-shade resin composites. BMC Oral Health 2023;23:367.
42. Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. Dent Mater 2006;22:211-22.
43. Ayaz EA, Durkan R, Koroglu A, Bagis B. Comparative effect of different polymerization techniques on residual monomer and hardness properties of PMMA-based denture resins. J Appl Biomater Funct Mater 2014;12:228-33.
44. Wei YJ, Silikas N, Zhang ZT, Watts DC. Diffusion and concurrent solubility of self-adhering and new resin-matrix composites during water sorption/desorption cycles. Dent Mater 2011;27:197-205.
45. Zankuli MA, Devlin H, Silikas N. Water sorption and solubility of core build-up materials. Dent Mater 2014;30:e324-9.
46. Takamizawa T, Barkmeier WW, Tsujimoto A, Scheidel D, Erickson RL, Latta MA, *et al*. Mechanical properties and simulated wear of provisional resin materials. Oper Dent 2015;40:603-13.
47. Katheng A, Prawatvatchara W, Tonprasong W, Namano S, Kongkon P. Effect of postrinsing times and methods on surface roughness, hardness, and polymerization of 3D-printed photopolymer resin. Eur J Dent 2025;19:154-64.
48. Canché-Escamilla G, Duarte-Aranda S, Toledano M. Synthesis and characterization of hybrid silica/PMMA nanoparticles and their use as filler in dental composites. Mater Sci Eng C Mater Biol Appl 2014;42:161-7.

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