REVIEW PAPER

Effect of Artificial Saliva on the Flexural Strength of Heat-Polymerized PMMA, Auto-Polymerized Bis-acryl Composite, and Light-Polymerized UDMA Provisional Restorative Materials: An In-vitro Study

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ABSTRACT

Background: Provisional restorations are indispensable in fixed prosthodontics as they protect prepared teeth, maintain esthetics and function, and preserve periodontal health until placement of the definitive prosthesis. Their long-term clinical success depends largely on their mechanical properties, particularly flexural strength. Continuous exposure to saliva may adversely affect these materials through water sorption and hydrolytic degradation. Therefore, evaluation of their mechanical performance under simulated oral conditions is essential.

Aim: To evaluate and compare the effect of artificial saliva on the flexural strength of heat-polymerized PMMA, auto-polymerized bis-acryl composite, and light-polymerized UDMA provisional restorative materials.

Materials and Methods: Sixty-six standardized rectangular specimens were fabricated according to ISO recommendations and divided into six groups (n = 11). Heat-polymerized PMMA, light-polymerized UDMA, and auto-polymerized bis-acryl composite specimens were stored either under dry conditions or immersed in artificial saliva for 10 days. Flexural strength was evaluated using a three-point bending test on a Universal Testing Machine (UTM). Statistical analysis was performed using one-way ANOVA followed by post-hoc analysis, with the level of significance set at $p < 0.05$.

Results: Statistically significant differences were observed among the six experimental groups ($p < 0.001$). Auto-polymerized bis-acryl composite exhibited the highest mean flexural strength under both dry (704.59 MPa) and artificial saliva (678.77 MPa) conditions. Heat-polymerized PMMA demonstrated intermediate values (562.58 MPa in dry condition and 465.62 MPa after saliva immersion), whereas light-polymerized UDMA showed comparatively lower flexural strength (534.73 MPa in dry condition and 482.29 MPa after saliva immersion). Artificial saliva reduced flexural strength in all tested materials.

Conclusion: Artificial saliva adversely affected the flexural strength of all provisional restorative materials evaluated. Auto-polymerized bis-acryl composite demonstrated superior flexural strength,, followed by heat-polymerized PMMA, whereas light-polymerized UDMA exhibited the least favorable mechanical performance.

Keywords: Artificial saliva, Bis-acryl composite, Flexural strength, PMMA, UDMA, Universal Testing Machine.

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INTRODUCTION

Education is Provisional restorations are an integral component of fixed prosthodontic treatment, as they protect prepared teeth, maintain occlusal stability, preserve periodontal health, restore esthetics, and permit evaluation of function before placement of definitive restorations.[1,2] Since these restorations may remain in the oral cavity for varying periods, they must possess adequate mechanical properties to withstand functional and masticatory forces.[3]

Among the various provisional restorative materials available, heat-polymerized polymethyl methacrylate (PMMA), auto-polymerized bis-acryl composite resin, and light-polymerized urethane dimethacrylate (UDMA) are commonly used. Their mechanical properties vary considerably depending on factors such as polymer composition, filler content, polymerization mechanism, and degree of conversion.[4,5] Studies have demonstrated considerable differences in the flexural strength of provisional restorative materials, with some bis-acryl materials exhibiting higher flexural strength than conventional methacrylate-based resins.[4,6]

Flexural strength is one of the most important mechanical properties of provisional restorative materials because these restorations are subjected to bending stresses during mastication and functional activities.[3,4] Inadequate flexural strength may result in fracture, marginal deterioration, loss of occlusal stability, patient discomfort, and increased chairside time.[4,6]

The oral environment continuously exposes provisional restorations to saliva, moisture, variations in pH, and temperature fluctuations. Water sorption may cause plasticization of the polymer matrix and hydrolytic degradation, thereby compromising the mechanical properties of polymeric restorative materials, particularly their flexural strength.[7,8]

The influence of the oral environment on provisional restorative materials has been demonstrated in experimental studies. Haselton et al. evaluated the flexural strength of methacrylate-based and bis-acryl provisional resins following immersion in artificial saliva and reported substantial differences in flexural strength among the materials tested.[4] Similarly, Yanikoğlu et al. evaluated methacrylate-based and bis-acryl provisional materials after storage in different solutions and reported higher fracture strength for the bis-acryl materials compared with the traditional methacrylate resin.[6] These findings emphasize the importance of evaluating provisional restorative materials under conditions that simulate the oral environment.

Therefore, the present in-vitro study was undertaken to compare the effect of artificial saliva on the flexural strength of three commonly used provisional restorative materials, namely polymethyl methacrylate (PMMA), bis-acryl composite resin, and urethane dimethacrylate (UDMA).

MATERIALS AND METHODS

Determination of Sample Size

The sample size was estimated using the data following the biostatistical analysis and was obtained as total 66 samples, 11 samples per group keeping the power to 80% in the formula.

Methodology

Materials tested:

A total of 66 standardized rectangular blocks of specimens made from the provisional restorative materials were selected for the testing. These specimens were equally divided into six experimental groups (n=11):

I. Group A – Heat-polymerized PMMA (Dry)
II. Group B – Heat-polymerized PMMA (Artificial saliva)
III. Group C – Light-polymerized UDMA (Dry)
IV. Group D – Light-polymerized UDMA (Artificial saliva)
V. Group E – Auto-polymerized Bis-acryl Composite (Dry)
VI. Group F – Auto-polymerized Bis-acryl Composite (Artificial saliva)

Specimens assigned to saliva groups were immersed in artificial saliva for the predetermined storage period of 10 days, while control specimens were maintained under dry conditions for 10 days.

Sample Preparation

A total of 66 standardized specimens were prepared for the evaluation of flexural strength. The specimens were fabricated in the form of rectangular bars measuring 25 × 2 × 2 mm, according to the dimensions specified for the flexural strength test.

Steps for sample preparation

1. Preparation of mould:The metal die(25×50×2mm) was coated with a thin layer of petroleum jelly as a separating medium and embedded in poly vinyl siloxane putty to obtain a standardized negative mould in a brass flask.
2. Preparation of materials:The three provisional restorative materials—heat-polymerized PMMA, light-polymerized UDMA, and auto-polymerized bis-acryl composite—were manipulated strictly according to the respective manufacturer's instructions.
3. Filling of mould:The prepared material was introduced into the negative mould carefully to avoid incorporation of air bubbles and ensure complete adaptation.

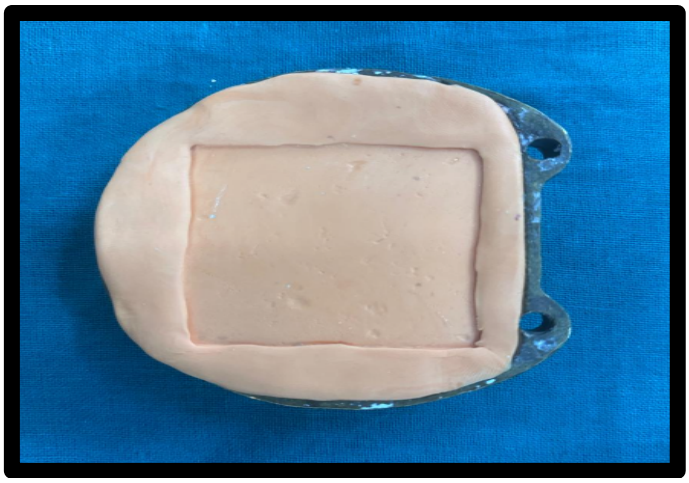


Figure 1: negative mould

4. Polymerization:
   - PMMA specimens were polymerized using the recommended heat-curing cycle.
   - UDMA specimens were polymerized using the recommended light-curing protocol.
   - Bis-acryl specimens were allowed to polymerize according to the manufacturer's recommended setting time.
5. Finishing and polishing:After polymerization, the specimens were carefully removed from the mould. Excess material was trimmed, and the surfaces were finished and polished without altering the standardized dimensions.
6. Dimensional verification:The dimensions of each specimen were checked using a digital vernier caliper to ensure uniformity before storage and testing.
7. Sectioning of specimens: The specimens were sectioned in the form of rectangular bars measuring 25 × 2 × 2 mm using die cutting machine.



Figure 2: Sectioning of specimens

8. Storage of specimens: The samples were stored in air thight containers for its protection from external impurities and moisture for 10 days. Groups A, C, and E were stored under dry conditions at room temperature. Groups B, D, and F were immersed in artificial saliva maintained at 37 ± 1°C to simulate the oral environment.

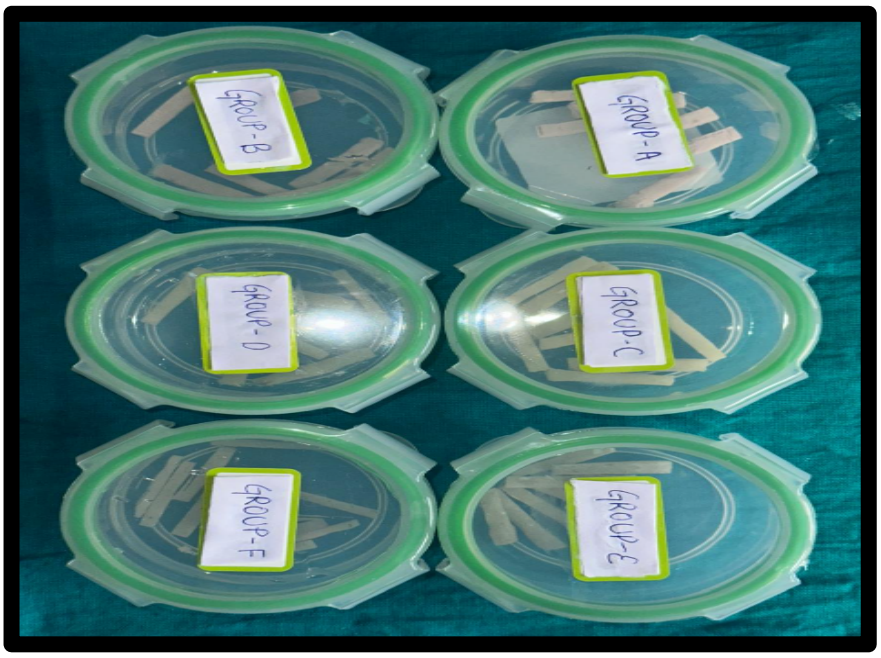


Figure3: Storage of specimen

Experimental Procedure

Flexural Strength Test

Flexural strength was evaluated using a three-point bending test using a Universal Testing Machine in accordance with ISO 10477:2018.

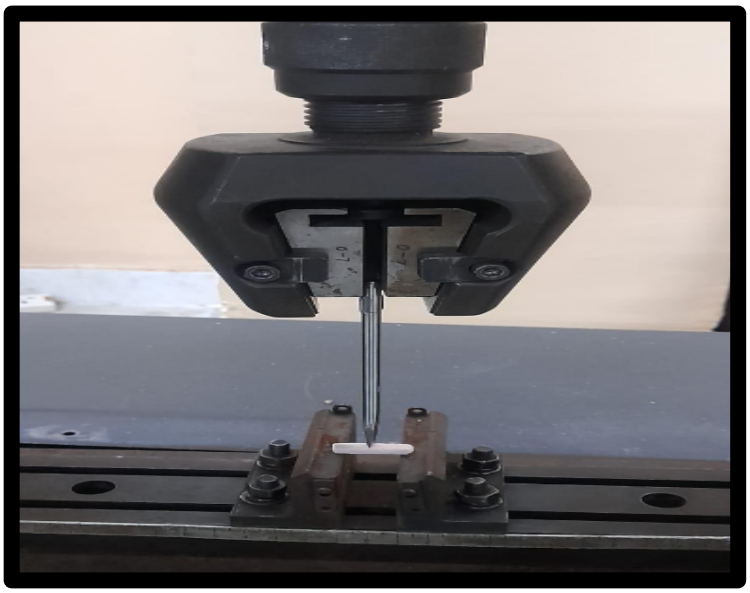


Figure 4: Universal Testing Machine

Flexural strength was calculated using the following equation:

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

where

- σ = Flexural strength (MPa)
- F = Fracture load (N)
- L = Distance between supports (mm)
- b = Width of specimen (mm)

- d = Thickness of specimen (mm)

RESULTS

Statistical analysis was performed using one-way ANOVA followed by appropriate post-hoc tests.

Table 1: "Intergroup comparison of flexural strength"

Group	N	Mean	SD	Std. Error	95% CI Lower	95% CI Upper	Minimum	Maximum
Group A	11	562.580	26.950	8.126	544.470	580.681	527.730	612.310
Group B	11	465.620	25.694	7.747	448.360	482.883	421.010	501.560
Group C	11	534.680	26.501	7.991	516.878	552.486	483.560	578.470
Group D	11	482.290	30.381	9.160	461.880	502.700	443.810	534.900
Group E	11	704.590	45.953	13.855	673.719	735.461	631.310	792.620
Group F	11	678.770	28.723	8.660	659.474	698.066	628.980	718.680
Total	66	**571.420**	**96.679**	**11.900**	**547.655**	**595.188**	**421.010**	**792.620**

Table 2: "One Way ANOVA"

Source of Variation	Sum of Squares	df	Mean Square	F value	p value	Interpretation
Between Groups	548059.639	5	109611.928	110.562	<0.001	Highly Significant
Within Groups	59484.465	60	991.408			
Total	607544.104	65				

Table 3: "Post Hoc Comparison"

Comparison	Mean Difference	p value	Interpretation
Group A vs Group B	96.954	<0.001	Significant
Group A vs Group C	27.894	0.042	Significant
Group A vs Group D	80.285	<0.001	Significant
Group A vs Group E	−142.015	<0.001	Significant
Group A vs Group F	−116.195	<0.001	Significant
Group B vs Group C	−69.060	<0.001	Significant

Group B vs Group D	−16.668	0.219	**Not significant**
Group B vs Group E	−238.968	<0.001	Significant
Group B vs Group F	−213.148	<0.001	Significant
Group C vs Group D	52.392	<0.001	Significant
Group C vs Group E	−169.908	<0.001	Significant
Group C vs Group F	−144.088	<0.001	Significant
Group D vs Group E	−222.300	<0.001	Significant
Group D vs Group F	−196.480	<0.001	Significant
Group E vs Group F	25.820	0.059	**Not significant**

The intergroup comparison of flexural strength revealed marked differences among the six experimental groups. The highest mean flexural strength was recorded in Group E (704.59 ± 45.95 MPa), followed by Group F (678.77 ± 28.72 MPa), while the lowest value was observed in Group B (465.62 ± 25.69 MPa). Groups A (562.58 ± 26.95 MPa), C (534.68 ± 26.50 MPa), and D (482.29 ± 30.38 MPa) demonstrated intermediate flexural strength values. One-way ANOVA showed a highly statistically significant difference among the groups ($F = 110.562$, $p < 0.001$), confirming that both the type of provisional material and the storage condition significantly influenced flexural strength.

Post hoc analysis indicated that most pairwise comparisons were statistically significant ($p < 0.05$). Group A differed significantly from all other groups (Groups B–F), suggesting that heat-polymerized PMMA stored in dry conditions performed distinctly compared to the other materials and storage conditions. Group B, representing heat-polymerized PMMA stored in artificial saliva, did not differ significantly from Group D, representing light-polymerized UDMA stored in artificial saliva ($p = 0.219$), indicating comparable flexural behavior between these two conditions. Groups E and F, representing auto-polymerized bis-acryl composite stored in dry conditions and artificial saliva, respectively, showed no statistically significant difference between them ($p = 0.059$), suggesting that storage condition had minimal impact on the flexural strength of the bis-acryl composite. Overall, the bis-acryl composite groups (E and F) demonstrated superior flexural strength compared with the PMMA (A and B) and UDMA (C and D) groups, irrespective of storage conditions.

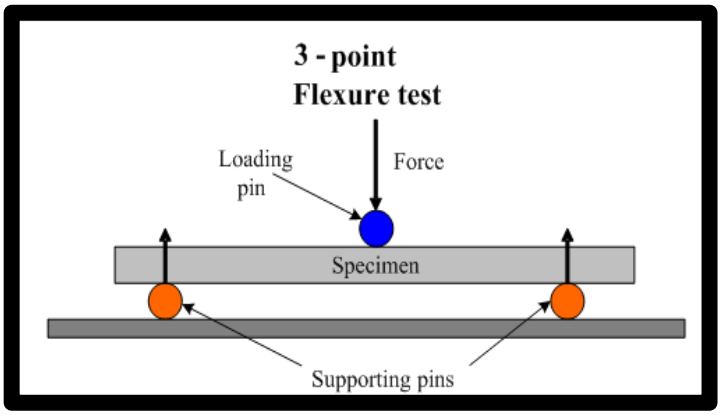


Figure 5: Testing of flexural strength

DISCUSSION

Provisional restorations must possess adequate mechanical strength to withstand functional stresses, particularly in long-span restorations and during prolonged provisionalization.[9,10] The present in-vitro study evaluated the effect of artificial saliva on the flexural strength of heat-polymerized polymethyl methacrylate (PMMA), auto-polymerized bis-acryl composite resin, and light-polymerized urethane dimethacrylate (UDMA) resin.

In the present study, auto-polymerized bis-acryl composite resin demonstrated the highest flexural strength among the materials tested. This superior performance may be attributed to its cross-linked polymer matrix and inorganic filler reinforcement, which enhance resistance to bending stresses and crack propagation. Similar findings have been reported by Haselton et al.,[10] who observed significant differences in flexural strength among provisional restorative materials. Yanikoğlu et al.[12] also reported higher flexural strength for bis-acryl provisional materials compared with methacrylate-based materials.

Heat-polymerized PMMA demonstrated intermediate flexural strength in the present study. The mechanical performance of PMMA may be influenced by its degree of polymerization, residual monomer content, molecular organization, and processing technique. Previous investigations have demonstrated that the mechanical properties of PMMA-based provisional materials vary according to the method of polymerization and fabrication.[9,11]

Artificial saliva generally reduced the flexural strength of the tested provisional restorative materials. This reduction may be associated with water sorption by the polymer matrix. Water molecules can penetrate the resin network and act as plasticizers, increasing polymer-chain mobility and weakening intermolecular interactions. Prolonged aqueous exposure may additionally promote hydrolytic degradation within the polymer matrix and at the resin-filler interface, thereby compromising mechanical properties.[11,12]

The magnitude of reduction following artificial-saliva exposure differed among the three materials. This finding suggests that resistance to aqueous aging is material dependent and may be influenced by resin chemistry, degree of conversion, cross-link density, filler characteristics, and water sorption. Previous investigations evaluating provisional materials after storage in aqueous media and artificial saliva have similarly demonstrated material-dependent changes in mechanical properties.[10,11,12]

Light-polymerized UDMA demonstrated comparatively lower flexural strength and greater susceptibility to reduction following exposure to artificial saliva. This behavior may be associated with differences in polymer network formation, degree of conversion, filler characteristics, and water uptake. Mehrpour et al.[11] reported significant differences in the flexural strength of interim restorative materials and found comparatively lower flexural strength for the light-polymerized material evaluated in their study. These findings support the material-dependent variation observed in the present investigation.

The findings of the present study are clinically relevant because provisional restorations may remain exposed to saliva for extended periods, particularly during complex prosthodontic rehabilitation, implant therapy, periodontal treatment, or long-term provisionalization. Materials with greater flexural strength and better resistance to degradation in the oral environment may provide improved resistance to fracture under functional loading. Based on the conditions of the present study, auto-polymerized bis-acryl composite resin demonstrated the greatest flexural strength, followed by heat-polymerized PMMA and light-polymerized UDMA.

Overall, the findings indicate that both material composition and storage conditions influence the flexural performance of provisional restorative materials. Artificial saliva should therefore be considered when evaluating their long-term mechanical behavior, as testing under dry conditions alone may not adequately represent their performance following intraoral exposure.[10,12]

The present investigation was conducted under in-vitro conditions and therefore cannot completely reproduce the complex oral environment. Intraorally, provisional restorations are simultaneously subjected to temperature fluctuations, variations in salivary pH, enzymatic activity, repeated masticatory loading, dietary substances, and other biological and mechanical factors. Future investigations incorporating thermocycling, thermomechanical aging, different salivary pH conditions, and cyclic fatigue loading are recommended. Further studies comparing conventional provisional materials with contemporary CAD/CAM-milled and three-dimensionally printed provisional materials may provide additional information regarding their suitability for long-term clinical use.

CONCLUSION

Within the limitations of this in-vitro study, the following conclusions were drawn based on the objectives of the research:

1. Artificial saliva influenced the flexural strength of the tested provisional restorative materials, although the magnitude of reduction varied according to the material.
2. Auto-polymerized bis-acryl composite resin demonstrated the highest flexural strength among the three materials evaluated, indicating superior mechanical performance under the conditions of the present study.

3. Heat-polymerized PMMA demonstrated intermediate flexural strength, with a reduction following storage in artificial saliva, indicating susceptibility to moisture-related changes.
4. Light-polymerized UDMA resin demonstrated comparatively lower flexural strength, with a greater reduction following artificial saliva storage, suggesting greater susceptibility to salivary aging.
5. The effect of artificial saliva was least pronounced for the auto-polymerized bis-acryl composite, as the difference between its dry and artificial-saliva groups was not statistically significant. This suggests comparatively better resistance to salivary degradation.

REFERENCES

1. Hattie J. Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 4th ed. St Louis: Mosby Elsevier; 2006.

2. Shillingburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of fixed prosthodontics. 3rd ed. Chicago: Quintessence Publishing; 1997.

3. Nejatidanesh F, Momeni G, Savabi O. Flexural strength of interim resin materials. J Prosthet Dent. 2009;101(6):386-391.

4. Digholkar S, Madhav VNV, Palaskar J. Evaluation of the flexural strength and microhardness of provisional crown and bridge materials fabricated using conventional, CAD/CAM, and 3D printing techniques. J Indian Prosthodont Soc. 2016;16(3):328-334.

5. Karaokutan I, Sayin G, Kara O. In vitro study of fracture strength of provisional crown materials. J Adv Prosthodont. 2015;7(1):27-31.

6. Yanikoğlu ND, Bayındır F, Kürklü D, Beşir B. Flexural strength of temporary restorative materials stored in different solutions. Open J Stomatol. 2014;4(6):291-298.

7. Al-Mulla MAS, Murphy WM, Huggett R, Brooks SC. The effect of water and artificial saliva on the dimensional stability of denture base acrylic resin. Dent Mater. 1989;5(6):399-402.

8. Balkenhol M, Ferger P, Mautner MC, Wöstmann B. Provisional crown and fixed partial denture materials: mechanical properties and degree of conversion. Dent Mater. 2007;23(12):1574-1583.

9. Osman YI, Owen CP. Flexural strength of provisional restorative materials. J Prosthet Dent. 1993;70(1):94-96.

10. Haselton DR, Diaz-Arnold AM, Vargas MA. Flexural strength of provisional crown and fixed partial denture resins. J Prosthet Dent. 2002;87(2):225-228. doi:10.1067/mpr.2002.121406.

11. Mehrpour H, Farjood E, Giti R, Barfi Ghasrdashti A, Heidari H. Evaluation of the flexural strength of interim restorative materials in fixed prosthodontics. J Dent (Shiraz). 2016;17(3):201-206.

12. Idrissi HA, Annamma LM, Sharaf D, Jaghsi AA, Abutayyem H. Comparative evaluation of flexural strength of four different types of provisional restoration materials: an in vitro pilot study. Children (Basel). 2023;10(2):380.