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TO EVALUATE AND COMPARE FLEXURAL STRENGTH AND POLYMERIZATION SHRINKAGE OF INTERIM PROSTHESIS MATERIALS USED IN FIXED PARTIAL PROSTHODONTICS - AN INVITRO STUDY

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ABSTRACT

Background: Interim prostheses are essential in fixed partial prosthodontics for maintaining function, esthetics, and periodontal health until definitive restorations are placed. Methods: This in vitro study compared heat-cured PMMA, bis-acryl composite resin, and light-cured resin using standardized specimens, evaluated for flexural strength via a three-point bending test and for polymerization shrinkage using dimensional measurements, followed by ANOVA analysis. Results: Bis-acryl composite resin showed the highest flexural strength, followed by PMMA and light-cured resin, while light-cured resin exhibited the least shrinkage and PMMA the highest, with statistically significant differences ($p < 0.05$). Conclusion: Bis-acryl offers superior strength, whereas light-cured resin provides better dimensional stability; thus, material selection should balance strength and accuracy based on clinical needs.

Introduction:

The success of a fixed partial denture (FPD) procedure depends greatly on provisional restoration, which serves as a temporary placeholder until the final prosthesis is fabricated.1 However, its role extends beyond space maintenance. It protects prepared teeth, preserves structural integrity, reduces sensitivity, and prevents bacterial invasion. It also enables evaluation of aesthetics, occlusion, and function, allowing necessary

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adjustments before definitive placement. Additionally, provisional restorations aid in tissue conditioning by guiding gingival contour for optimal periodontal health. Despite being termed “temporary,” they significantly influence the longevity and success of the final restoration, making their design and fabrication critical.2

Provisional restorations also provide a preview of the final prosthesis, helping manage patient expectations. They enhance abutment and periodontal health by minimizing trauma and promoting healing.3 Furthermore, they serve diagnostic and therapeutic purposes, allowing occlusal and functional modifications. Their resin-based occlusal surfaces facilitate customization for proper stomatognathic function.4

Although auto-polymerizing acrylic resins are commonly used, they may cause irritation due to residual monomer or heat generation. Newer materials such as bis-acryl composites and light-cured resins overcome these limitations. Temporary restorations must fulfil mechanical, biological, and aesthetic requirements during their service period. Studies show varying strength among materials, with bis-acrylics often demonstrating superior flexural strength.5 Polymerization shrinkage also differs significantly, with PMMA showing ~6% shrinkage compared to 1.0–1.7% in composites.

Thus, this study compares PMMA, bis-acryl, and light-cured resins based on flexural strength and shrinkage.

Method

Two Oratemp C and B and Revotek LC were among the temporary restorative materials used for the current study (Figure1, 2). They demonstrated the traits of these materials and were representative of the two categories of interim materials (self-cure, light cure). In accordance with ADA specification #27, specimens measuring 25 x 2 x 2 mm were created using a metallic mold. (Figure 9). Following the manufacturing company's directions, the samples were made utilizing a metallic mold and the interim restorative materials. Oratemp C&B (bis-acryl) were combined automatically with the help of the dispenser tip. Revotek LC (light cure) was manually added to the mold using a spatula. (Figure1,2,3). To remove extract the material from the mold and generate the required pressure, a weight was fastened on the glass slab that was placed on the mold's surface. (Figure4) Samples were removed from the mold after the polymerization process, and any air bubbles were visually inspected. The study did not include problematic specimens.

GROUPING OF SAMPLES

The specimens were divided into two groups based on the kind of resin that was used. Group 1 used Revotek-LC, a resin that hardens under light, while Group 2 used Oratemp CandB, a self-setting resin. Following standard procedures, the two materials were used to create two test groups, each with 28 samples (totaling 56 samples). The samples were carefully polished as per the manufacturer’s guidelines (Figure 9). From each group, 14 samples (28 in total) were submerged in artificial

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saliva and kept at 37°C for 10 days to simulate oral conditions. The fracture force was converted from Newton to MPa using the following formula: Flexural strength is denoted by S in this equation, maximal fracture force by F, specimen length by L, specimen width by W, and specimen height by H. Analyzed the data with one-way ANOVA and unpaired t-tests to compare differences both between groups and within subgroups. For every statistical test, we considered results significant if the p-value was less than 0.05.

Checking how much it can flex before breaking

Two groups of material were prepared, each containing 14 samples of Specimen A (28 samples total). Each sample was cut to 25x2x2 mm, following ADA specification #27, to meet the requirements for flexural strength testing. The samples were roughly shaped using a tungsten carbide bur and then smoothed with sandpaper and diamond polishing paste. After preparation, the samples were soaked in artificial saliva at 37°C for 10 days. For testing, each sample was placed on a Universal Testing Machine (INSTRON, Model No. 3382, Lloyds, England) for a three-point bend test (Figure 13). The setup included two supporting pins (2 mm diameter each), spaced 10 mm apart, with a third loading pin of the same diameter applying force. The test ran at a crosshead speed of 0.75 mm/min using a 10 kN load cell (Figure 14).

Evaluating shrinkage during polymerization

A total of 28 samples from Group B were prepared, divided into two groups of 14 each, to test polymerization shrinkage. First, the samples were roughly shaped with a tungsten carbide bur, then smoothed with sandpaper and polished with diamond abrasive paste. To measure shrinkage, an optical stereomicroscope was used, with the device automatically recording the readings. A computer system then analyzed the data to provide precise dimensional and geometric measurements (Figure 15). Testing was done at three intervals: 10 minutes, 20 minutes, and 120 minutes after preparation. Statistical analysis (using SPSS version 21.0) revealed differences between the groups based on material type and time.

STATISTICAL ANALYSIS

Data was entered into a Microsoft Excel spreadsheet and was checked for any discrepancy. Briefed data is presented using various colorful tables and graphs. Statistical analysis is done using SPSS (version 20). Descriptive statistics included mean, standard deviation (SD), and standard error of the mean. To compare the effectiveness of the interventions, a one-way ANOVA was performed to assay differences in GPI scores among the groups. Since ANOVA revealed a statistically significant difference, the Bonferroni multiple comparison test was applied as a post hoc test to assess pairwise differences between groups while controlling for Type I error.

Results

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Data was entered into Microsoft Excel spread sheet and was checked for any discrepancies. Summarized data was presented using Tables and Graphs. The data was analysed by SPS (21.0 version). Shapiro Wilk test was used to check which all variables were following normal distribution. Data was normally distributed for polymerization shrinkage values therefore; inferential statistics were performed using the parametric test i.e. independent t test. For comparison of flexural strength, Mann Whitney U test was used as data failed follow the normal distribution. Level of statistical significance was set at p-value less than 0.05 (*). Table 1: The flexural strength of the samples in Group A ranges from approximately 76.84 MPa to 117.46 MPa. The polymerization values for these samples vary between approximately 1.08% and 4.77%.

Table 1: Measurement of flexural strength and Polymerisation shrinkage for Group A (Light Cure) samples

1	Group 1 (Light cure material (UDMA)-Revotek LC)	88.41	3.08
2	Group 1 (Light cure material (UDMA)-Revotek LC)	100.06	2.65
3	Group 1 (Light cure material (UDMA)-Revotek LC)	92.19	2.05
4	Group 1 (Light cure material (UDMA)-Revotek LC)	88.14	4.09
5	Group 1 (Light cure material (UDMA)-Revotek LC)	79.65	2.82
6	Group 1 (Light cure material (UDMA)-Revotek LC)	95.21	3.27
7	Group 1 (Light cure material (UDMA)-Revotek LC)	80.63	1.07
8	Group 1 (Light cure material (UDMA)-Revotek LC)	112.42	3.47
9	Group 1 (Light cure material (UDMA)-Revotek LC)	117.45	3.44
10	Group 1 (Light cure material (UDMA)-Revotek LC)	76.84	3.46
11	Group 1 (Light cure material (UDMA)-Revotek LC)	105.42	4.77
12	Group 1 (Light cure material (UDMA)-Revotek LC)	87.02	3.72
13	Group 1 (Light cure material (UDMA)-Revotek LC)	89.76	2.43
14	Group 1 (Light cure material (UDMA)-Revotek LC)	114.79	2.74

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Table 2: The flexural strength values range from approximately 51.42 MPa to 118.50 MPa for Group B samples. For polymerization shrinkage, the measurements in Group B range from approximately 1.24% to 4.95%.

S. NO.	Table 2: Measurement of polymerization shrinkage in Group B	Flexural strength	Polymerisation shrinkage
1	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	54.97	3.79
2	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	56.09	1.24
3	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	51.41	3.66
4	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	108.28	3.68
5	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	104.47	1.84
6	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	110.90	1.51
7	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	118.50	2.26
8	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	105.94	2.45
9	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	82.30	3.28
10	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	104.63	2.75
11	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	58.27	4.95
12	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	94.79	1.40
13	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	60.03	1.83
14	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	116.12	1.64

Table 3: The Kolmogorov-Smirnov test yields a statistic of 0.133 for flexural strength with a p-value of0.20, which is above the standard threshold of 0.05, suggesting that the data does not significantly deviate from a normal distribution according to this test. However, the Shapiro-Wilk test results in a statistic of 0.922 with a p-value of 0.039, which is below .05. This indicates a possible deviation from normality for the flexural strength measurements according to the Shapiro-Wilk test. Both the Kolmogorov-Smirnov (statistic = 0.092, p = 0.200) and Shapiro-Wilk (statistic = 0.973, p = 0.664) tests yield p-values greater than0.05, indicating no significant deviation from normality for the polymerization shrinkage data.

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Table 3: Tests of Normality to measure flexural strength and polymerisation shrinkage						
Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	P value	Statistic	Df	P value
Flexural strength	0.13	0.28	0.20*	0.92	0.28	0.03
Polymerisation shrinkage	0.09	0.28	0.20*	0.97	0.28	0.66
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Table 4: The intergroup comparison of flexural strength between Group 1 (light-cure material, UDMA-Revotek LC) and Group B (self-cure material, BISACRYLIC-Oratemp C&B) reveals that, on average, the light-cure material exhibits a slightly higher flexural strength than the self-cure material. Specifically, Group 1 has a mean flexural strength of 94.85 ± 13.28 MPa, whereas Group B has a mean flexural strength of 87.62 ± 25.89 MPa. The Mann-Whitney U test yielded a p-value of 0.351, which is above the conventional significance level of 0.05. Thus, the difference in flexural strength between the two groups is not statistically significant, indicating that both materials offer comparable flexural strength overall.

Table 4: Intergroup comparison of Flexural strength					
		N	Mean	Std. Deviation	Std. Error Mean
Flexural strength	Group 1 (Light cure material (UDMA)-Revotek LC)	14	94.85	13.28	3.55
	Group B(Self cure material (BISACRYLIC)-Oratemp C&B)	14	87.62	25.89	6.92
P value					0.35

Graph 1: Intergroup comparison of Flexural strength

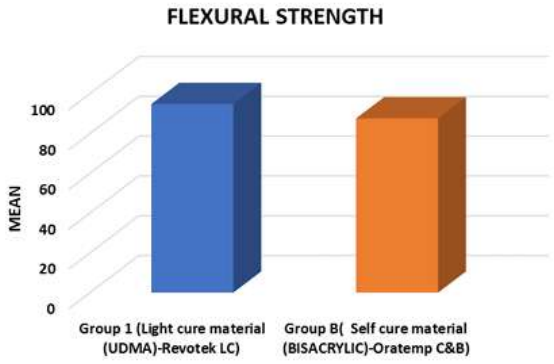

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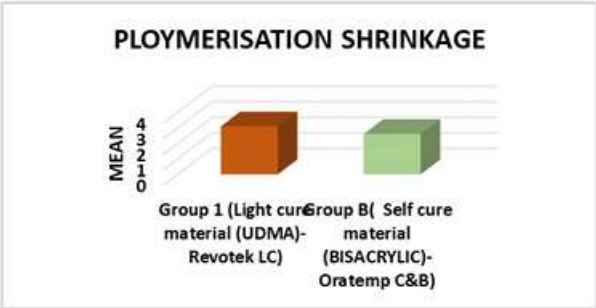
Table 5: The intergroup comparison of polymerization shrinkage between Group 1 (light- cure material, UDMA-Revotek LC) and Group B (self-cure material, BISACRYLIC- Oratemp C&B) shows a slightly higher average shrinkage in the light-cure material. Specifically, Group 1 has a mean polymerization shrinkage of 3.08 ± 0.904%, while Group B exhibits a lower mean shrinkage of 2.60 ± 1.123%. The light-cure material demonstrates more consistent shrinkage values, indicated by a lower standard deviation, whereas the self- cure material shows slightly higher variability in shrinkage. An independent t-test was used to assess the significance of this difference, yielding a p-value of 0.218, which is above the 0.05 threshold. This result indicates that the difference in mean polymerization shrinkage between the two materials is not statistically significant.

Table 5 : Intergroup comparison of Polymerisation shrinkage

		N	Mean	Std. Deviation	Std. Error Mean
Polymerisation shrinkage	Group 1 (Light cure material (UDMA)-Revotek LC)	14	3.08	0.90	0.24
	Group B(Self cure material (BISACRYLIC) -Oratemp C&B)	14	2.595	1.12	0.30
				P value	0.21



Graph 2: Fifteen Intergroup comparison of Polymerisation shrinkage

DISCUSSION

The purpose of this research was to assess and contrast flexural strength and polymerization shrinkage of two provisional restorative materials used in fixed partial dentures. The following groups have been compared for this study. GROUP 1: Consisted total of 28 samples which were sub grouped as 1a and 1b with 14 each

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sample. (Figure9a) GROUP 2: Consisted total of 28 samples which were sub grouped as 2a and 2b with 14 each sample. (Figure9b) The study used an Instron universal testing machine to measure the flexural strength of two temporary crown materials after soaking them in artificial saliva for ten days. Flexural strength reflects how a material holds up under both stretching and squeezing forces, showing its ability to withstand steady pressure. While the test results don't perfectly match real-world mouth conditions, they allow for a controlled comparison between materials. These findings can guide dentists in choosing the right temporary restorative materials based on whether they prioritize aesthetics or function.36 Flexural testing helps evaluate how materials perform under simple beam loading. Flexible materials like composites, wood, and plastics are often tested this way. There are two main methods: three-point and four-point bending. The three-point test creates a small, highly stressed area right under the loading point, while the 4-point test spreads the stress more evenly between two inner points. In bending tests, the surface of the sample experiences the most stress. For this study, a rectangular sample was tested using the 3-point bending method.14 Saliva, food ingredients, drinks, and interactions between these items can all affect the flexural strength of temporary materials. When a material is utilized over an extended period of time, the changes that take place when it was exposed to different temperature regulations should be evaluated. One such procedure that weakens the material and mimics changes inthe oral environment was immersion in fake saliva. Oratemp displayed statistically significant differences ($p < 0.05$), while Revotek LC and Integrity showed no notable variation. These findings mostly matched the data in Table 3. Revotek LC had much lower flexural strength and standard deviation values (Table 5), likely because of changes in its material structure—specifically, the bis-acryl groups reducing the resin's toughness and flexibility.41

Flexural strength

Kolbeck et al. reported that glass fibres reinforce resins more effectively than polyethylene fibres due to better adhesion.36 In agreement, this study found comparable flexural strength between light-cure UDMA (Revotek LC, Group 1: 94.85 ± [value] MPa) and self-cure bis-acryl (Oratemp C&B, Group B: 87.62 ± 25.89 MPa; 13.28 MPa noted), with no significant difference ($p = 0.351 > 0.05$).30 All materials exceeded the minimum 50 MPa requirement (ANSI/ADA No. 27; ISO 4049), confirming clinical suitability. Oratemp showed better strength due to cross-linking and hydrophobicity.42,45 Revotek LC was weaker due to filler loss.37 Polymerization shrinkage was slightly higher in Revotek LC (3.08 ± 0.904%) than Oratemp (2.60 ± 1.123%), but not significant ($p = 0.218$).27 PMMA shrinks ~6%, composites 1.0–1.7%. Shrinkage ranged 1.08–4.77% and 1.24–4.95%, while flexural strength ranged 76.84–117.46 MPa and 51.42–118.50 MPa.34 Revotek LC showed highest shrinkage; Oratemp least ($p < 0.05$). Overall, shrinkage affects fit and performance.

Null hypothesis

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The null hypothesis that provisional composite restorative materials could not affect flexibility and polymerisation shrinkage of the temporary prosthesis (Oratemp C&B, Revotek LC)materials used in Fixed Partial Denture, was rejected as per the positive findings of the result analysis.

Generated hypothesis

The generated hypothesis that provisional composite restorative materials could affect polymerisation shrinkage and flexural strength of temporary prosthesis materials (Oratemp C&B, Revotek LC), was accepted as per the positive findings of the result analysis.

LIMITATIONS OF THE STUDY

1. In Vitro Nature of the Study

2. Sample Size and Statistical Power

3. Material Variations

4. Environmental factors (temperature and humidity during the curing process or testing)

5. Differences in curing time, light intensity, or chemical curing methods for resin-basedmaterials

6. Dimensional changes

7. Testing Methods-The mechanical tests (e.g., three-point bending test for flexural strength) may not fully mimic the functional forces encountered by provisional materials in a clinical setting.

8. Duration of the Study- In an in vitro study, the evaluation is typically conducted over a short period of time. The long-term behaviour of materials in terms of flexural strength and polymerization shrinkage is not assessed.

CLINICAL RECOMMENDATIONS:

When selecting interim materials, clinicians should prioritize materials with a balance between adequate flexural strength and minimal polymerization shrinkage. Ideally, materials with low shrinkage should be preferred to ensure proper marginal adaptation and to avoid post-treatment complications. The selection of material should also be based on the clinical situation (posterior vs. anterior teeth, patient habits, and anticipated occlusal forces) and patient comfort during the provisional period. Regular follow-ups should be scheduled to assess the integrity of the provisional restoration, especially for materials with known high shrinkage or low strength.

Conclusion:

Self-cure bis-acrylic materials showed higher flexural strength, making them better suited for provisional dental restorations that need to withstand strong forces.

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However, choosing the right temporary material isn't just about strength—it also depends on factors like ease of use, stain resistance, polish ability, and appearance. Since long-term provisional restorations are more prone to staining (especially from liquid absorption), aesthetics becomes a major concern. This study found that even just 10 days of soaking in liquids caused noticeable staining, suggesting that light-cure urethane Di methacrylate is a better choice for long-term Provisionals, particularly in visible areas like front teeth. Beyond looks, provisional restorations must also handle functional pressure, especially in patients with habits like teeth grinding. That's why durability matters more than convenience—materials with high flexural strength and low shrinkage, like bis-acrylics, are often preferred. While this study tried to mimic real-world conditions, it couldn't fully replicate clinical reality. For example, in actual practice, provisional crowns are loaded immediately after placement, but in this experiment, they were stored in artificial saliva for 10 days before testing.

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