

RESEARCH PAPER

Comparative Evaluation Of The Flexural Strength Of Commercially Available Provisional Restorative Materials With And Without Incorporation Of Glass Fibre: An In Vitro Study

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ABSTRACT

Background: Provisional restorations are integral to fixed prosthodontic treatment, protecting prepared abutments and preserving function and esthetics until delivery of the definitive prosthesis. Flexural strength is a critical mechanical property governing the clinical performance of provisional materials, and fibre reinforcement has been proposed to enhance this property.

Aim: To compare the flexural strength of two commercially available provisional restorative materials, Protemp 4 and Tran Temp, with and without incorporation of glass fibre.

Materials and Methods: This in vitro comparative study was conducted in the Department of Prosthodontics and Crown & Bridge, Desh Bhagat Dental College and Hospital, Mandi Gobindgarh. Seventy-two three-unit provisional bridge specimens were fabricated on a standardized typhodont model and divided into four groups of 18 specimens each: Group A, Protemp 4 (unreinforced); Group B, Protemp 4 reinforced with glass fibre; Group C, Tran Temp (unreinforced); and Group D, Tran Temp reinforced with glass fibre. All specimens were loaded to fracture on a Universal Testing Machine (20 kN capacity) at a crosshead speed of 5 mm/minute. Data were analysed using one-way ANOVA followed by the Bonferroni post-hoc test (SPSS v26.0; $\alpha = 0.05$).

Results: Group B (Protemp 4 + glass fibre) recorded the highest mean flexural strength (0.800 ± 0.215 MPa), followed by Group C (Tran Temp, 0.530 ± 0.188 MPa), Group D (Tran Temp + glass fibre, 0.519 ± 0.282 MPa), and Group A (Protemp 4, 0.411 ± 0.414 MPa). One-way ANOVA showed a statistically significant difference among groups ($F = 5.939$, $p = 0.001$). Bonferroni post-hoc comparison showed Group B was significantly higher than Group A ($p = 0.001$), Group C ($p = 0.039$), and Group D ($p = 0.029$); no other pairwise comparisons reached statistical significance.

Conclusion: Glass fibre reinforcement significantly improved the flexural strength of Protemp 4 but produced no statistically significant benefit in Tran Temp, indicating that the effect of glass fibre reinforcement on provisional restorative resins is material-dependent.

Keywords: Provisional restorative material; Flexural strength; Glass fibre reinforcement; Bis-acryl resin; Fixed partial denture; In vitro study.

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1. INTRODUCTION

Loss of one or more teeth, whether from caries, trauma, congenital absence, endodontic failure, or periodontal disease, compromises both masticatory efficiency and facial esthetics, and prosthodontic rehabilitation aims to restore function, appearance, and speech by replacing the missing dentition.¹ Among the treatment options available for partially edentulous patients, the fixed partial denture (FPD) remains one of the most durable and widely used solutions, and has long been considered a gold-standard approach to restoring form and function.^{2,3}

Fabrication of a definitive FPD typically requires 7-10 days, during which the prepared abutment must be shielded from the oral environment and the existing occlusal and inter-arch relationships preserved a process achieved through temporization. The terms provisional, interim, and transitional restoration are used interchangeably in the literature to describe these interim prostheses, which protect pulpal and periodontal tissues, prevent abutment migration, and maintain occlusion throughout treatment.^{4,5}

Provisional restorative materials are broadly classified by chemical composition into monomethacrylate-based resins (e.g., polymethylmethacrylate and polyethyl/butyl methacrylate) and dimethacrylate-based, light- or chemically-cured bis-acryl composites (e.g., Bis-GMA and UDMA systems). Advances in resin chemistry have refined these materials for direct chairside use, improving clinical efficiency while reducing time and cost.^{6,7} Material selection should nonetheless be guided by how well its mechanical, physical, biocompatibility, and handling characteristics meet the demands of the individual clinical case.⁸

Among the various properties assessed, flexural strength the ability of a material to resist deformation and fracture under bending forces is regarded as one of the most clinically relevant parameters, since provisional restorations, particularly long-span FPDs, are subjected to repeated masticatory and para-functional loading during service. Inadequate flexural strength can result in marginal breakdown, crack propagation, or outright fracture, compromising both function and periodontal health.⁹ Several

reinforcement strategies have therefore been explored to improve the mechanical performance of provisional resins, including incorporation of polyethylene, carbon, and glass fibres, often combined with silane coupling agents to optimize fibre-matrix bonding.^{6,10} Glass fibres in particular have attracted attention for their favourable mechanical properties, chemical stability, and ease of chairside or laboratory incorporation into resin-based provisional materials.

Despite these advances, the response of a given provisional resin to fibre reinforcement is not uniform across products, and manufacturer claims of enhanced strength require independent verification under standardized laboratory conditions before they can inform clinical material selection. The present in vitro study was therefore undertaken to comparatively evaluate the flexural strength of two commercially available provisional restorative materials, Protemp 4 and Tran Temp, with and without incorporation of glass fibre, to provide evidence-based guidance for material and reinforcement selection in fixed prosthodontics.

2. MATERIALS AND METHODS

2.1 Study Design

This in vitro, comparative, experimental study was conducted in the Department of Prosthodontics and Crown & Bridge, Desh Bhagat Dental College and Hospital, Desh Bhagat University, Mandi Gobindgarh, Punjab, India. The study evaluated and compared the flexural strength of two commercially available provisional restorative materials, with and without incorporation of glass fibre, under standardized loading conditions.

2.2 Materials Used

The consumable materials used were: Protemp 4 (3M ESPE), a bis-acryl composite provisional restorative material; Tran Temp Crown (Nexobio; product code NEX 01310), an automix 1:1, bis-acrylic composite temporary crown-and-bridge material; Type IV die stone (Shruti “Ultra Real” Die Stone); a typhodont model (API); modelling wax (Maarc Dental); a vinyl polysiloxane putty and light-body impression material

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(Flexceed); industrial-grade optic glass fibre; diamond burs; and petroleum jelly (Vaseline) used as a separating medium (Figure 1). Non-consumable equipment included dispensing guns, a laboratory

micromotor with burs, and a perforated stock metal impression tray. Flexural loading was performed on a Universal Testing Machine of 20 kN capacity (Model WDW-20; Jinan, M/s CTMC).



Figure 1. Materials used in the study. (A) Protomp 4 (3M ESPE); (B) Tran Temp Crown (Nexobio, NEX 01310); (C) Type IV die stone; (D) Typhodont model; (E) Industrial-grade optic glass fibre; (F) Vinyl polysiloxane putty and light-body impression material with dispensing gun.

2.3 Experimental Groups and Sample Size

The minimum sample size per group was calculated using a standard formula for comparative in vitro study designs (allowable error $d = 2\%$, $s = 3\%$), which yielded a calculated minimum requirement of approximately 17-18 specimens per group, rounded up to 18. A total of 72 three-unit provisional bridge specimens were accordingly fabricated and equally divided into four groups of 18 specimens each:

- Group A Protomp 4, unreinforced ($n = 18$)
- Group B Protomp 4 reinforced with glass fibre ($n = 18$)
- Group C Tran Temp, unreinforced ($n = 18$)
- Group D Tran Temp reinforced with glass fibre ($n = 18$)

2.4 Specimen Preparation

A three-unit FPD tooth preparation was standardized on a typhodont model using diamond burs. An

impression was made in a perforated stock metal tray using vinyl polysiloxane putty and light-body material, and a working cast was poured. A wax pattern was fabricated on the cast, invested, and cast in a cobalt-chromium alloy to obtain a precision metal master die, which was duplicated in Type IV die stone for each experimental group. A putty index was prepared over the pre-preparation typhodont cast to standardize the dimensions of each provisional restoration.

The die was coated with a thin layer of Vaseline as a separating medium, and the respective provisional material was dispensed from the automix gun into the putty index, which was seated over the die until the material had fully set. After setting, each provisional bridge was carefully retrieved without distortion, and all specimens were finished and polished using a laboratory micromotor and burs to obtain smooth surfaces and uniform margins (Figure 3).

2.5 Glass Fibre Reinforcement

For Groups B and D, industrial-grade (optic) glass fibre strands were cut and incorporated randomly within the resin bulk during material dispensing to achieve even distribution prior to seating in the putty index. Reinforced specimens were finished and polished using the same protocol as the unreinforced groups.

2.6 Flexural Strength Testing

All 72 specimens were loaded to fracture on a Universal Testing Machine (20 kN capacity, Model WDW-20; Jinan, M/s CTMC; calibration validity 21 March 2026) at an ambient temperature of 24.2°C. A stainless-steel loading pin of 2 mm diameter was positioned at a standardized site on each specimen, and load was applied at a crosshead speed of 5 mm/minute until fracture. The load at fracture was recorded automatically by the UTM software for each specimen and used as the outcome measure for between-group comparison.

2.7 Statistical Analysis

Data were analysed using SPSS software (version 26.0; SPSS Inc., Chicago, IL, USA). Descriptive

statistics (mean, standard deviation, standard error, 95% confidence interval, minimum, and maximum) were computed for each group. Normality of distribution was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Between-group comparisons were performed using one-way analysis of variance (ANOVA), followed by the Bonferroni post-hoc test for pairwise comparison. A p -value < 0.05 was considered statistically significant.

3. RESULTS

A total of 72 specimens (18 per group) were tested to fracture; no specimen was excluded from analysis.

3.1 Normality of Distribution

Normality testing using the Kolmogorov-Smirnov and Shapiro-Wilk tests showed significance values greater than 0.05 for all four groups (Table 1), indicating no significant deviation from a normal distribution. Parametric statistical tests (one-way ANOVA and the Bonferroni post-hoc test) were therefore considered appropriate for between-group comparison.

Table 1. Normality testing (Kolmogorov-Smirnov and Shapiro-Wilk tests).

Group	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Protemp 4 (Group A)	.119	18	.223	.940	18	.165
Protemp 4 + glass fibre (Group B)	.147	18	.200*	.983	18	.187
Tran Temp (Group C)	.153	18	.133	.994	18	.234
Tran Temp + glass fibre (Group D)	.182	18	.119	.921	18	.134

*Lilliefors significance correction. All p -values > 0.05 , consistent with a normal distribution in all four groups.

3.2 Descriptive Statistics

Descriptive statistics for flexural strength in each group are presented in Table 2. Group B (Protemp 4 + glass fibre) recorded the highest mean flexural strength (0.800 ± 0.215), with a relatively low standard deviation indicating consistent performance among specimens (95% CI: 0.693-0.907). Group A (Protemp 4, unreinforced) recorded the lowest mean

flexural strength (0.411 ± 0.414), with the widest range of values (0.091-1.792) and the greatest variability among the four groups (95% CI: 0.205-0.616). Group C (Tran Temp, unreinforced) recorded a mean of 0.530 ± 0.188 , while Group D (Tran Temp + glass fibre) recorded a comparable mean of 0.519 ± 0.282 ; the 95% confidence intervals for Groups C and D overlapped considerably, indicating no meaningful difference between them (Figure 5).

Table 2. Descriptive statistics of flexural strength by group.

Group	N	Mean	SD	SE	95% CI	Min	Max
Protemp 4 (A)	18	.41050	.413825	.097539	.20471-.61629	.091	1.792

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Protemp 4 + glass fibre (B)	18	.79972	.215270	.050740	.69267-.90677	.226	1.063
Tran Temp (C)	18	.52972	.188215	.044363	.43613-.62332	.183	.880
Tran Temp + glass fibre (D)	18	.51944	.281949	.066456	.37923-.65965	.156	1.159

Values reported as stated in the source thesis (unit “MPa” as used in the original text)

3.3 Between-Group Comparison (One-Way ANOVA)

One-way ANOVA revealed a statistically significant difference in flexural strength among the four groups ($F = 5.939$; $df = 3, 68$; $p = 0.001$) (Table 3). The

between-group mean square (0.494) was appreciably larger than the within-group mean square (0.083), confirming that the observed differences were unlikely to be due to random variation and that material type and reinforcement status significantly influenced flexural strength.

Table 3. One-way ANOVA comparison of flexural strength.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.481	3	.494	5.939	.001*
Within Groups	5.653	68	.083		
Total	7.134	71			

*Statistically significant at $p < 0.05$.

3.4 Bonferroni Post-Hoc Pairwise Comparison

Pairwise comparison using the Bonferroni test (Table 4) showed that Group B (Protemp 4 + glass fibre) had significantly higher flexural strength than Group A (Protemp 4; mean difference = 0.389, $p = 0.001$), Group C (Tran Temp; mean difference = 0.270, $p = 0.039$), and Group D (Tran Temp + glass fibre; mean

difference = 0.280, $p = 0.029$). No statistically significant difference was found between Group A and Group C ($p = 1.000$), Group A and Group D ($p = 1.000$), or Group C and Group D ($p = 1.000$). These findings indicate that glass fibre reinforcement significantly enhanced the flexural strength of Protemp 4, but had no significant effect on Tran Temp.

Table 4. Bonferroni pairwise post-hoc comparison of flexural strength.

(I) Group	(J) Group	Mean Diff. (I-J)	SE	Sig.	95% CI
Protemp 4 (A)	Protemp 4 + GF (B)	-.38922*	.096106	.001*	-.65040 - -.12804
	Tran Temp (C)	-.11922	.096106	1.000	-.38040 -.14196
	Tran Temp + GF (D)	-.10894	.096106	1.000	-.37013 -.15224
Protemp 4 + GF (B)	Tran Temp (C)	.27000*	.096106	.039*	.00882 - .53118
	Tran Temp + GF (D)	.28028*	.096106	.029*	.01910 - .54146
Tran Temp (C)	Tran Temp + GF (D)	.01028	.096106	1.000	-.25090 -.27146

*The mean difference is significant at the 0.05 level. GF = glass fibre.

4. DISCUSSION

Provisional restorations must withstand repeated functional and para-functional occlusal loading during the interim period before delivery of the definitive prosthesis, and flexural strength is widely regarded as one of the most clinically relevant mechanical parameters for predicting their in-service performance.⁹ Inadequate flexural strength can result

in marginal breakdown, crack propagation, or outright fracture, particularly in long-span fixed partial dentures, with consequent risk to pulpal and periodontal health.^{9,11} Because manufacturer claims of superior strength require independent verification under standardized laboratory conditions,¹² and because the early mechanical behaviour of provisional materials within the first 10 to 30 minutes after fabrication can influence their subsequent resistance to functional deformation,¹³ the present in vitro study

comparatively evaluated the flexural strength of Protemp 4 and Tran Temp, with and without glass fibre reinforcement.

In the present study, glass fibre reinforcement significantly improved the flexural strength of Protemp 4 (Group B versus Group A), whereas the corresponding effect in Tran Temp (Group D versus Group C) was small and statistically non-significant. This material-dependent response to fibre reinforcement is consistent with previous reports. Kamble et al.¹⁴ compared PMMA and bis-acryl composite resins reinforced with different fibre types and found that glass-fibre reinforcement produced a marked increase in flexural strength over unreinforced controls. Naveen et al.¹⁵ similarly reported that silane-treated unidirectional glass fibres provided the greatest improvement in flexural strength among interim fixed dental prosthesis specimens, while unreinforced specimens performed the poorest. Idrissi et al.¹⁷ and Mehrpour et al.¹⁸ likewise reported significant differences in flexural strength across provisional materials, reinforcing the conclusion that both material composition and reinforcement status are key determinants of mechanical performance.

The more favourable response of Protemp 4, a bis-acryl composite, to glass fibre incorporation compared with Tran Temp may relate to differences in resin matrix chemistry and fibre-matrix bonding between the two materials, although the present study did not directly assess fibre-resin interfacial adhesion. Poonacha et al.¹⁶ reported that methyl methacrylate resin outperformed bis-acrylic and light-polymerized resins in flexural strength across multiple time intervals, underscoring that baseline material chemistry, independent of reinforcement, substantially influences mechanical outcome. Singh et al.^{19,20} similarly found that both the type of provisional material and the presence of glass fibre reinforcement significantly affected flexural strength outcomes, and Rawat²¹ reported that glass-fibre-reinforced PMMA outperformed both polyethylene-fibre-reinforced and unreinforced bis-acryl specimens.

The absence of a significant reinforcing effect for Tran Temp in the present study is, to the best of the present authors' knowledge, among the first in vitro evaluations of this specific material's flexural behaviour with and without glass fibre reinforcement, and no directly comparable published data exist for Tran Temp for direct comparison. This finding should be interpreted cautiously, as it may reflect differences in resin composition, fibre distribution, or fibre-matrix adhesion specific to Tran Temp, rather than a generalizable limitation of glass fibre reinforcement as a strengthening strategy.

Clinically, these findings suggest that the benefit of glass fibre reinforcement of provisional restorations cannot be assumed uniformly across all commercially

available materials, and clinicians selecting a reinforcement strategy for long-span or high-load provisional restorations should consider the base material's inherent response to fibre incorporation. As this was an in vitro study using standardized specimens under static loading, these findings should not be directly extrapolated to clinical performance without further evaluation; intraoral conditions such as thermocycling, moisture exposure, and cyclic masticatory loading may influence flexural behaviour differently from the controlled laboratory setting used here.

4.1 Limitations

- This was an in vitro study conducted under static loading to fracture, which does not fully replicate the cyclic, moist, and thermally variable intraoral environment.
- Only two commercially available provisional materials and a single fibre type and incorporation protocol were evaluated; findings cannot be generalized to other provisional resins or reinforcement fibres.
- Specimen span, width, and thickness, and the formula used to derive the reported flexural strength from the recorded fracture load, are not detailed in the original study records and require confirmation.
- The effect of clinically relevant aging factors, such as water storage or thermocycling, on flexural strength over time was not evaluated.

5. CONCLUSION

Within the limitations of this in vitro study, incorporation of glass fibre significantly improved the flexural strength of Protemp 4 but did not produce a statistically significant improvement in Tran Temp, indicating that the effectiveness of glass fibre reinforcement in provisional restorative resins is material-dependent. Protemp 4 reinforced with glass fibre exhibited the highest and most consistent flexural strength among the four groups evaluated, while unreinforced Protemp 4 exhibited the lowest and most variable strength. These findings suggest that material-specific considerations should guide the selection of provisional restorative materials and reinforcement strategies in clinical situations demanding higher flexural strength, such as long-span provisional fixed partial dentures.

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