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Original Research Article

Comparative evaluation of bond strength of pre-heated composite and flowable composite

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Abstract

Introduction: Composites are rapidly advancing with variations in composition and variable properties that can adapt well with the clinical demand and aesthetic concerns. Studies on pre-heated composites date back to the 2010s. They have recently been added to routine clinical practices. Their properties are much like flowable composites but what about their bond strength?

Aim: The aim of the study is to compare the bond strength of pre-heated composite and flowable composite with conventional composite.

Materials and Methods: Sixty sound extracted premolars were used. They were divided into three groups with twenty samples in each group. Enamel on the buccal aspect of all the fifteen teeth was removed with diamond saw and dentin was exposed. Bonding agent was applied. Cylindrical moulds of uniform size 5×7 mm were adapted on prepared tooth surface. Group A, the control group was bonded with conventional composite. Group B specimens were bonded with pre-heated composite. Group C specimens were bonded with flowable composite. The bond strength between the tooth and restoration of all sixty samples were measured using universal testing machine.

Result: All 3 tested groups showed statistically significant difference in their bond strength ($p<0.05$). Specimens which withstood maximum load without fracture exhibited higher bond strength. Group A required a mean force of 252.564N; group B- 135.437 and Group C- 68.4043 respectively.

Conclusion: Group A- Conventional composite has superior bond strength; followed by pre-heated composite. The flowable composite has the least bond strength.

Keywords: Bond strength, Flowable composite, Pre-heated composite, Conventional composite

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1. Introduction

Composites are widely used in restorative and aesthetic dentistry nowadays. Dr. Rafael Bowen created the first dental composite in 1954 using inorganic fillers and acrylic polymer. From there-on the evolution of composite has been outbreaking. From basic composites to light curable; then to microfilled and later nanofilled; hybrid; packable and flowable composites were introduced and had various applications in dentistry. Today research is focused on smart composites; composites with less shrinkage and on improving various physical properties.

In the mid-1990s, flowable composites were developed wherein the low viscosity permits the composite to shape itself to fit cavity areas that are difficult to access. The studies on preheated composites date back to 2000s. Chairside warming of resin-based restorative materials, prior to placement and contouring, is one of the recent trends in composite application.[1] Preheating reduces viscosity and increases flowability and gives better marginal adaptation.[2] Their wide clinical usage has been observed in the 2020s.

There are various studies[3,4,5] on properties of pre-heated composite and their applications. But no study has compared the bond strength of pre-heated composite with that of flowable composite.

Hence the aim of the present study is to compare the bond strength of pre-heated composite and flowable composite with conventional composite.

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2. Materials and Methods

2.1. Study design

Experimental In-vitro study

2.2. Study setting

1. The study is set up in the Department of Conservative Dentistry & Endodontics, Sree Anjaneya Institute of Dental Sciences, Modakkallur, Kozhikode, Kerala.
2. The fracture resistance test is to be conducted at NIT, Kozhikode, Kerala.

2.3. Sample size calculation

$$n = 2 \times \frac{\left(\frac{z\alpha}{2} + Z\beta\right)}{(d1 - d2^2)} \times SD^2$$

Zα/2 = Type I error (5%) =1.96

Zβ = Type II error (20%) = 1.28 (power of the study = 80%)

SD = Standard deviation = 5 (From literature)

d1–d2 = difference in mean = 4.5

$$n = \frac{2 \times (1.96+0.84)^2 \times 5^2}{(4.5)^2}$$

$$= 2 \times \frac{7.84 \times 25}{20.25} = 19.35 \approx 20 \text{ (per group)}$$

2.4. Groups considered in the study

1. Group A-the control group, to be bonded with conventional/ non-heated composite.
2. Group B-to be bonded with pre-heated composite.
3. Group C-to be bonded with flowable composite

3. Methodology

Sixty sound extracted caries-free premolars extracted for orthodontic treatment needs were used in the study. They were collected cleaned with scalers and stored in distilled water containing 0.5% chloramine T. **(Figure 1)** Chloramine T act as a disinfectant and protect the teeth from microorganism present.

Figure 1: Teeth stored in chloramine T

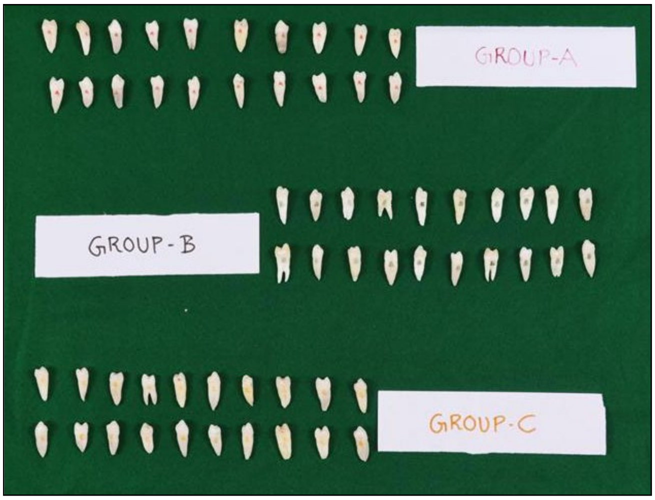


Figure 2: Samples divided into 3 groups

a b

Figure 3: (a) Diamond Saw (b) Enamel on buccal aspect removed

Figure 4: Cylindrical mould

Figure 5: specimens embedded in acrylic

Figure 6: Preheating device

They were divided into three groups with twenty samples in each group. **(Figure 2)**

1. Group A-the control group, to be bonded with conventional/ non-heated composite.
2. Group B-to be bonded with pre-heated composite.
3. Group C-to be bonded with flowable composite

Enamel on the buccal aspect of all 60 teeth were removed using a diamond saw. **(Figure 3)** A 2 step etch and rinse adhesive system was applied on the teeth surface. Cylindrical moulds of uniform size 5×7 mm was fabricated for composite build up on natural tooth. **(Figure 4)**

Group A teeth were placed with composite (Ivoclar Tetric N ceram Shade A2) and cured as per manufacturer's instructions (Ivoclar Bluephase NMC). For group B, the preheated group, the composite was pre-heated (Delta-composite warmer) **(Figure 5)** for 5 minutes prior to bonding and were luted and cured. For group C, the mould was placed, and flowable composite (Ivoclar) was applied in increment and cured. All specimens were then embedded in cold cure acrylic block of 10×2 cm dimension. **(Figure 6)**

4. Assessment of SBS

Shear bond strength was analyzed using universal testing machine (Shimadzu) at a cross-sectional speed of 1mm/min. **(Figure 7)**. The specimens were engaged between the jigs of the machine. A constant load was applied with a sharp stylus at the junction of restoration and the tooth surface until fracture occurred. The values at which fracture occurred were recorded. **(Table 1)**

Figure 7: Universal testing machine

5. Statistical Analysis

Data was analyzed using the statistical package **SPSS 26.0** (SPSS Inc., Chicago, IL) and level of significance was set at **$p<0.05$**. **Descriptive statistics** was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using **Shapiro Wilkinson test**. **Inferential statistics** to find out the difference between the groups was done using **ONE WAY ANOVA TEST followed by Tukey's HSD test**.

6. Result

Table 1: Test results

Group A (Conventional)	Maximum force for fracture (N)	Group B (Pre-heated)	Maximum force for fracture(N)	Group C (Flowable)	Maximum force for fracture (N)
A1	269.354	B1	127.229	C1	82.3859
A2	268.455	B2	127.241	C2	81.7692
A3	266.387	B3	127.826	C3	82.8761
A4	267.987	B4	130.896	C4	82.5619
A5	269.321	B5	132.766	C5	82.8916
A6	253.242	B6	128.998	C6	81.0987
A7	260.582	B7	128.908	C7	81.7324
A8	264.564	B8	127.877	C8	80.9843
A9	263.897	B9	128.932	C9	80.9812
A10	264.242	B10	128.889	C10	79.9956
A11	264.568	B11	129.238	C11	82.0087
A12	266.543	B12	127.843	C12	81.6754
A13	260.908	B13	129.022	C13	80.1765
A14	260.098	B14	128.897	C14	81.7651
A15	257.908	B15	127.435	C15	80.6341
A16	268.124	B16	127.987	C16	80.7613
A17	269.221	B17	129.876	C17	82.8761
A18	257.98	B18	128.942	C18	81.9872
A19	266.943	B19	129.934	C19	81.7803
A20	265.876	B20	128.463	C20	81.7638

Table 2: Descriptive details

Descriptive Statistics								
	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Non Heated	20	16	253	269	264.31	1.007	4.505	20.299
Pre Heated	20	5.54	127.23	132.77	128.8599	.29511	1.31977	1.742
Flowable	20	2.90	80.00	82.89	81.6353	.19296	.86294	.745

Table 3: Normality testing

Tests of Normality						
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
G1	.163	20	.168	.907	20	.055
G2	.201	20	.063	.878	20	.117
G3	.169	20	.139	.947	20	.325
a. Lilliefors Significance Correction						

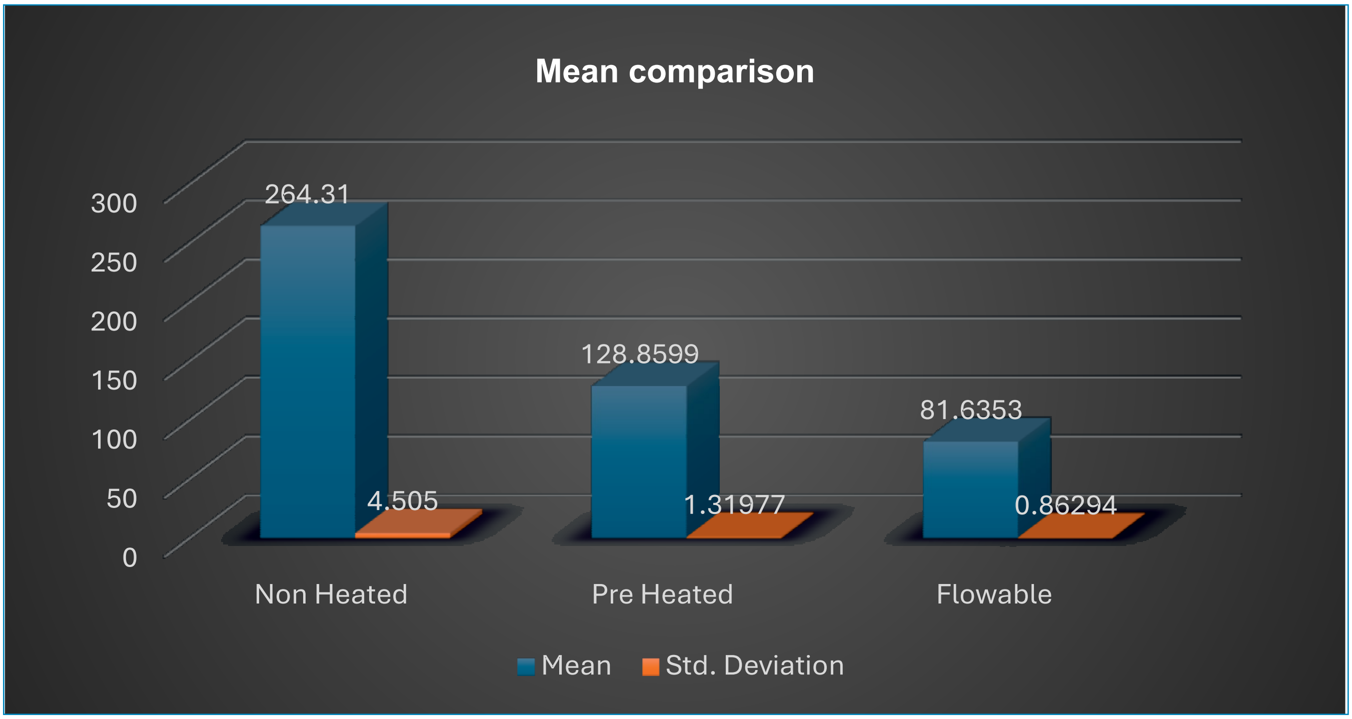
Table 4: One way anova statistics

ANOVA					
Mean					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	359646.290	2	179823.145	23676.263	.000
Within Groups	432.920	57	7.595		
Total	360079.209	59			

One way anova reported statistically significant difference between the three study groups as follows Non heated> Pre Heated > Flowable($p<0.05$)

Table 5: Posthoc comparison

Multiple Comparisons						
Dependent Variable: Mean						
Tukey HSD						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Non Heated	Pre Heated	135.4500*	.8715	.000	133.353	137.547
	Flowable	182.6747*	.8715	.000	180.578	184.772
Pre Heated	Non Heated	-135.4500*	.8715	.000	-137.547	-133.353
	Flowable	47.2247*	.8715	.000	45.127	49.322
Flowable	Non Heated	-182.6747*	.8715	.000	-184.772	-180.578
	Pre Heated	-47.2247*	.8715	.000	-49.322	-45.127
*. The mean difference is significant at the 0.05 level.						



Graph 1: Mean comparison of SBS

Descriptive statistics **(Table 2)** show that Group A- Conventional composite withstood maximum force without fracture with a mean value of 264.31+/- 4.505 N. The pre-heated group followed the conventional group by withstanding 128.8599+/- 1.31977 N and Group B, the flowable composite group showed immediate fracture as they could withstand 81.6353 +/-0.86294 N only. **(Graph 1)**

Normality testing, **(Table 3)** displays the results of normality tests for three groups (G1, G2, and G3) using two statistical methods: the Kolmogorov-Smirnov test and the Shapiro-Wilk test. Each test examines whether the data distribution in the respective group significantly deviates from a normal distribution. In both the Kolmogorov-Smirnov and Shapiro-Wilk tests, none of the p-values are below 0.05, suggesting no significant deviation from normality in any of the three groups. The Shapiro-Wilk test is generally more powerful for small sample sizes, and here it consistently shows higher p-values across the groups, reinforcing the assumption of normality. The data for all three groups (G1, G2, G3) appears to be normally distributed based on the results of both normality tests.

(Table 4) presents the results of a one-way Analysis of Variance (ANOVA) conducted to examine whether there are statistically significant differences in means across three groups. A very high F-statistic (23876.263) combined with a p-value of .000 indicates strong evidence of a statistically significant difference in means among the groups. The between-group variance is overwhelmingly larger than the within-group variance, reinforcing the conclusion that the group means are not equal. The ANOVA test confirms that there is a highly significant difference in means among the three groups, meaning that at least one group mean is significantly different from the others.

Posthoc comparison **(Table 5)** displays the results of a Tukey HSD (Honestly Significant Difference) post hoc test. This analysis was performed after a significant one-way ANOVA to identify which specific group means differ significantly from one another. All comparisons show statistically significant differences ($p < 0.001$). The largest difference in means is between the Flowable and Non Heated groups. The smallest, yet still significant, difference is between the Pre Heated and Flowable groups. The Tukey HSD test reveals that each pair of treatment groups differs significantly from the others. This supports the earlier ANOVA result, indicating that the effect of the treatment type on the dependent variable is statistically significant across all groups.

7. Discussion

Achieving a strong, long-lasting bond between composite materials and tooth or ceramic substrates is a cornerstone of restorative dentistry. Among the various composite types, conventional high-viscosity composites, pre-heated composites, and flowable composites each offer distinct advantages and limitations. A growing body of in vitro and clinical research consistently ranks conventional composites highest in bond strength, pre-heated composites in the mid-range, and flowable composites at the lower end. This discussion synthesizes key findings, explores the underlying mechanisms, and assesses clinical implications.

The aim of the study was to compare the bond strength of conventional composites, pre heated composites and flowable composite.

Conventional composites is the benchmark for bond strength. Their high filler content and viscosity contribute towards their properties. They are often considered the standard for adhesive performance. A 2021 meta-analysis compared self-adhesive flowable composites with conventional composites bonded using separate adhesive systems. The authors concluded, "The bond strength of self-adhesive flowable composite resins is lower than that of conventional composite resins," reinforcing the superiority of conventional systems.[3]

Pre-heating conventional composites (typically to 54–68 °C) temporarily reduces viscosity, improving adaptation while retaining the mechanical strength of the original material. Operative Dentistry reports that lowering viscosity via pre-heating enhances interfacial adaptation without compromising post-cure properties such as hardness or conversion.[3,4] Studies have shown that pre-heated composite and flowable composite have reduced viscosity and increased flowability when compared to conventional composites.[5,6] Preheating the composite resin resulted in thinner luting interfaces, with a more intimate interaction between resin and adhesive layer.[7] Bond strength studies highlight that pre-heated composites often exceed flowable options and can even rival resin cements in ceramics. For example, one study concluded, "preheated viscous composite is an excellent material in cementation of lithium disilicate ceramic restorations"[8,9] Along with their excellent marginal adaptation, they have reduced marginal leakage and enhance durability of restoration. Another study noted flowables were not recommended for PICN (polymer-infiltrated ceramics) due to their low bond strength, while pre-heated composites emerged as viable alternatives.[9]

The clinical application of pre-heated composite is a great challenge as they have a very short working time.

Taufin et al[10] confirms that pre-heated composites, used for Class I restorations, show 100% retention at 18 months—equivalent to non-heated composites—when proper bonding techniques are followed.

Daronch et al.[11], reported that a composite preheated to 60°C can lose 35-40% of its heat in 40 s after being removed from the heat source. After 2 min 50% drop in temperature. After 5 minutes 90% drop in temperature. By the time the material is light-cured, The temperature will have reached a level at which an increase in molecular mobility becomes improbable. No optimization of mechanical properties would be achieved.

A composite's temperature rise increases the mobility of both radicals and monomers, producing a high degree of monomer conversion[12,13] and an increase in the rate of polymerization.[14] Better mechanical and physical qualities as well as more highly cross-linked polymer networking may be anticipated as a result. Daronch and colleagues computed the conversion rate of a preheated composite and discovered that heating the resin composites to 1408F (608C) raised the conversion rate from 31.6% to 67.3%, indicating a reduction in the amount of time needed for polymerization.[3] Deb and colleagues showed that preheating has no effect on the cytocompatibility of composites.[6]

Flowable composite, self-etching or using an adhesive system, are valued for their low viscosity and better wetting of cavity walls, but this comes at the expense of mechanical and adhesive properties. Their reduced filler content and higher polymerization shrinkage makes them less suitable for high-load restorations. Flexural and bond strengths of flowables are notably weaker immediately after curing: "flowable and bulk-fill flowable composites are much lower immediately after polymerization than after 24 hours.[15] Additionally, their bond strengths to enamel and dentin remain consistently inferior to conventional counterparts have properties inferior to that of conventional composite.[3,15] Their advantage lies in their consistency and ease of placement without disturbing the underlying pulp tissue; and perform acceptably in low-stress settings or when used as liners under conventional composites.

Mechanism behind bond strength differences could be explained by material properties like viscosity and adaptation; filler content; polymerization shrinkage; C factor and thermal and mechanical stability. Conventional composites contain higher filler loads (60–85 wt %) compared with flowables (37–53 wt %), resulting in greater mechanical strength and reduced shrinkage. While conventional composites suffer from higher viscosity, pre-heating overcomes this temporarily; flowables naturally possess better adaptation due to their lower viscosity[4] Lower filler content in flowables leads to increased polymerization shrinkage (2–3.5%) and internal stress, exacerbated in high C-factor cavities (e.g., Class I, C-factor = 5). Pre-heated composites, if cured promptly, may mitigate shrinkage stress by forming thinner layers and improving adaptation . Flowables exhibit improved flexural modulus over 24 hours, but remain weaker than conventional materials. Pre-heated composites maintain or even enhance conversion and hardness, without detrimental effects from heating cycles.

8. Limitation of Study

1. Being a primary study, a large sample size could have been considered.
2. In the present in-vitro study, no periodontal simulation was done to access the fracture resistance.
3. Composite was bonded on the buccal surface of premolars which had little correlation in the clinical scenario.

9. Conclusion

Within the limitations of the study,

1. **Conventional composites** provide the highest bond strength and serve as the clinical benchmark.
2. **Pre-heated composites** offer intermediate bond strength with improved adaptation, making them suitable for both direct restorations and ceramic cementation—so long as handling protocols are strictly followed.
3. **Flowable composites**, while easy to manipulate, consistently exhibit the lowest bond strengths due to lower filler content, greater shrinkage, and poorer mechanical properties, thus limiting their use to non-load-bearing roles or liners.

Dental professionals can optimize outcomes by selecting each composite type based on its unique properties: conventional composites are ideal for providing strong structural support, pre-heated composites improve marginal adaptation and are suitable for aesthetic cementation, while flowable composites are best confined to low-stress areas and precise detailing. Ongoing research into long-term outcomes and optimal pre-heating protocols will further enhance restorative success in clinical practice.

10. Source of Funding

None.

11. Conflict of Interest

None.

References

1. D'Amario M, De Angelis F, Vadini M, Marchili N, Mummolo S, D'Arcangelo C. Influence of a repeated preheating procedure on mechanical properties of three resin composites. *Oper Dent*. 2015;40(2):181–9. doi: 10.2341/13-238-L.
2. Froes-Salgado NR, Silva LM, Kawano Y, Francci C, Reis A, Loguercio AD. Composite pre-heating: Effects on marginal adaptation, degree of conversion and mechanical properties. *Dent Mater*. 2010;26(9):908–14. doi: 10.1016/j.dental.2010.03.023.
3. David C, de Cardoso GC, Isolan CP, Piva E, Moraes RR, Cuevas-Suarez CE. Bond strength of self-adhesive flowable composite resins to dental tissues: A systematic review and meta-analysis of in vitro studies. *J Prosthet Dent*. 2022;128(5):876–85. doi: 10.1016/j.prosdent.2021.02.020.
4. Wanger WC, Aksu MN, Neme AL, Linger JB, Pink FE, Walker S. Effect of pre-heating resin composite on restoration microleakage. *Oper Dent.*2008;33(1):72–78. doi: 10.2341/07-41
5. Lucey S, Lynch CD, Ray NJ, Burke FM, Hannigan A. Effect of pre-heating on the viscosity and microhardness of a resin composite. *J Oral Rehabil*. 2010;37(4):278–82. doi: 10.1111/j.1365-2842.2009.02045.x.
6. Deb S, Di Silvio L, Mackler HE, Millar BJ. Pre–warming of dental composites. *Dent Mater*. 2011;27(4):e51–59. doi: 10.1016/j.dental.2010.11.009.
7. Goulart M, Veleda BB, Damin D, Ambrosano GMB, de Souza FHC, Erhardt MCG. Preheated composite resin used as a luting agent for indirect restorations: effects on bond strength and resin-dentin interfaces. *Int J Esthet Dent*. 2018;13(1):86–97.
8. Shahin IG, Mohsen C, Katamish H. Comparison between bond strength of lithium disilicate with preheated composite, flowable composite and resin cement. *Egypt Dent J.* 2021;67(3): 2407–11. doi: 10.21608/edj.2021.71338.1575
9. Grangeiro MTV, da Silva Rodrigues C, Rossi NR, Souza KB, de Melo RM, Bottino MA. Preheated composite as an alternative for bonding feldspathic and hybrid ceramics: a microshear bond strength study. *J Adhes Dent.* 2023;25:159–166. doi: 10.3290/j.jad.b4279775
10. Taufin N, Priyadarshini BI, Shankarappa P, Ballullaya SV, Devalla S, Gavini S. Eighteen-month clinical performance of preheated nanoceramic resin-based composites in Class I occlusal cavities: A randomized clinical trial. *J Conserv Dent*. 2022;25(1):47–53. doi: 10.4103/jcd.jcd_492_21
11. Daronch M, Rueggeberg FA, Moss L, de Goes MF. Clinically relevant issues related to preheating composites. *J Esthet Restor Dent*. 2006;18(6):340–50. doi: 10.1111/j.1708-8240.2006.00046.x
12. El-Korashy DI. Post-gel shrinkage strain and degree of conversion of preheated resin composite cured using different regimens. *Oper Dent*. 2010;35(2):172–9. doi: 10.2341/09-072-L.
13. Morais A, Santos ARAD, Giannini M, Reis AF, Rodrigues JA, Arrais CAG. Effect of pre-heated dual-cured resin cements on the bond strength of indirect restorations to dentin. *Braz Oral Res*. 2012;26(2):170–6. doi: 10.1590/s1806-83242012000200014.
14. Holanda DBV, França FMG, do Amaral FLB, Flório FM, Basting RT. Influence of preheating the bonding agent of a conventional three-step adhesive system and the light activated resin cement on dentin bond strength. *J Conserv Dent*. 2013;16(6):536–9. doi: 10.4103/0972-0707.120965.
15. Tsujimoto A, Irie M, Teixeira ECN, Jurado CA, Maruo Y, Nishigawa G, et al. Relationships between Flexural and Bonding Properties, Marginal Adaptation, and Polymerization Shrinkage in Flowable Composite Restorations for Dental Application. *Polymers*. 2021;13(16):1–13. doi: 10.3390/polym13162613.

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