

## ORIGINAL ARTICLE

# Effect of adhesive techniques and preheated composite resin types as luting agents on shear bond strength of lithium disilicate: an experimental study

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## ABSTRACT

**Introduction:** The success of veneers is influenced by the cementation procedure. Preheated composite resin has been proposed as a luting material for indirect adhesive restorations because of its improved mechanical and handling properties. Composite resin bonds effectively to tooth structures using adhesive systems. This study aimed to evaluate the effect of different adhesive application techniques and types of preheated composite resin as luting materials on the shear bond strength of lithium disilicate. **Methods:** Twenty-eight extracted maxillary premolars were prepared on the buccal surface to expose dentin and divided into four experimental groups. Lithium disilicate discs (3 mm in diameter and 1 mm in thickness) were cemented onto the prepared surfaces according to the assigned group protocols. Group IA received preheated microhybrid composite with total-etch adhesive, IB received self-etch adhesive; IIA received preheated nanohybrid composite with total-etch adhesive, and IIB received self-etch adhesive. After cementation, the samples were immersed in artificial saliva at 37°C for 24 hours. Shear bond strength testing was conducted using a universal testing machine. Debonded samples were observed under a stereomicroscope to determine bonding failure. Data were analyzed using two-way ANOVA and post hoc LSD tests with a 95% confidence level. **Results:** Total-etch adhesive demonstrated higher shear bond strength (SBS) than self-etch adhesive for both composite types. The highest SBS was observed in the total-etch microhybrid group ( $14.03 \pm 0.12$  MPa), followed by the total-etch nanohybrid group ( $12.99 \pm 0.09$  MPa) and the self-etch microhybrid group ( $13.67 \pm 0.18$  MPa), while the lowest value was recorded in the self-etch nanohybrid group ( $10.21 \pm 0.22$  MPa) **Conclusion:** Preheated microhybrid composite resin produced higher shear bond strength with lithium disilicate than preheated nanohybrid composite resin, and the total-etch adhesive technique resulted in higher shear bond strength than the self-etch technique.

## KEYWORDS

Composite resin, dental adhesives, etching, shear strength, temperature

## INTRODUCTION

One of the biggest challenges in esthetic dentistry is the restoration of anterior teeth. The use of veneers has increased in recent years due to their better aesthetics and minimally invasive techniques.<sup>1</sup> The success of veneers is greatly influenced by the cementation procedure, therefore the choice of cementation material is an most important factor.<sup>2</sup>

Resin cement is the standard cementation material for indirect restorations.<sup>3</sup> The resin cement types include dual-cure, self-cure, and light cure resin cement.

The disadvantages of dual-cure resin cement are low viscosity and the requirement to mix two components, which poses a risk of bubble formation. In addition, it can cause color changes due to amine activators.<sup>4</sup> Self-cure resin cement is not indicated as a cementation material for thin ceramic restorations because it has lower color stability.<sup>5</sup> Light cure resin cement is recommended as a veneer cementation material due to its better color stability, easy manipulation, and adequate working time. However, low inorganic filler content can increase polymerization shrinkage and produce a higher coefficient of thermal expansion compared to enamel and dentin.<sup>3</sup>

Currently, composite resin has been used as an alternative material for indirect restoration cementation.<sup>6</sup> Composite resin contains higher filler and lower initiator concentration, resulting in improved physical properties, allowing good restoration margins, color stability, and resistance to wear in the oral environment. In addition, composite resin does not contain chemical activators associated with long-term color changes.<sup>7</sup> However, monomers with high molecular weight and inorganic filler content increase the viscosity of composite resin compared to resin cement.<sup>8</sup> Viscosity can be reduced by preheating composite resin without affecting other properties, allowing it to be used as an alternative material for cementation.<sup>9</sup>

Various studies have investigated different filler types in preheated composite resins.<sup>10</sup> When the material is heated, the flowability of nanohybrid composite resin increases, with film thickness and viscosity decreasing by approximately 25%, while the film thickness of microhybrid composites decreases by approximately 30% when the material is heated. This is due to differences in the quantity, composition, and average size of filler particles.<sup>11</sup>

Composite resin cannot bond chemically to hard tooth tissue, so an adhesive material is needed.<sup>12</sup> An important factor that influences the clinical success of an indirect restoration is the adhesive material protocol used.<sup>13</sup> Adhesive materials can significantly increase the long-term durability of indirect restorations due to chemical and micromechanical bonds.<sup>14</sup> Universal adhesive materials have been introduced since 2011 and represent the development of seventh-generation adhesive materials.<sup>15</sup> These adhesives offer high flexibility and can be adapted to various etching application techniques, including etch-end-rinse, self-etch, and selective-enamel-etch techniques that can be applied to all types of dental substrates. This simplifies the application procedure and improves efficiency in clinical practice.<sup>16</sup>

The novelty of this study lies in evaluating the combined effect of adhesive strategies and preheated composite resin types on bonding performance with lithium disilicate. This study hypothesized that the type of preheated composite resin and the adhesive application technique affect the shear bond strength of lithium disilicate, with a potential interaction between the two variables. This study aimed to analyze the influence of different adhesive application techniques and types of preheated composite resin as luting materials on the shear bond strength of lithium disilicate.

## METHODS

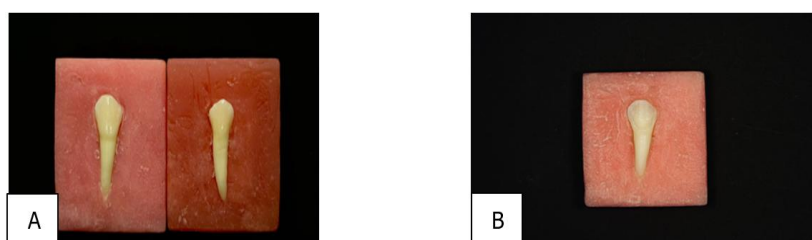
This experimental study was conducted at the Integrated Research Laboratory Faculty of Dentistry of Gadjah Mada University and Materials Laboratory Faculty of Engineering Department of Mechanical Engineering, Yogyakarta State University. This study used a pure experimental post-test-only control group design.

According to Federer, the number of samples used in this study was 28 upper premolar teeth and 28 lithium disilicate discs (IPS e.max Press, Ivoclar Vivadent AG, Schaan, Liechtenstein) with a diameter of 3 mm and a thickness of 1 mm (ISO 6872). The samples were randomly divided into four treatment groups, each consisting of seven samples. These groups were: group IA, preheated microhybrid composite resin (3M, Saint Paul, Minnesota, USA) with a total-etch adhesive

application technique; group IB, preheated microhybrid composite resin with a self-etch adhesive (3M Company, Maplewood, Minnesota, USA) application technique; group IIA, preheated nanohybrid composite resin (3M, Saint Paul, Minnesota, USA) with a total-etch adhesive (3M Company, Maplewood, Minnesota, USA) application technique; and group IIB, preheated nanohybrid composite resin with a self-etch adhesive application technique.

The cold-cured acrylic powder beads were mixed with monomer in a 3:1 ratio and poured into a custom-made split mold constructed from mild steel (ST37) measuring 3.5 cm x 3.5 cm x 1 cm. The teeth were then positioned carefully before the acrylic resin hardened in a horizontal position. The hardened acrylic resin was removed from the mold (Figure 1A).

The buccal surface of the teeth was reduced by 1.4 mm to reach the dentin layer with a depth-cutting bur. The prepared surface was marked with waterproof ink and the preparation was leveled using a round end fissure bur to the depth of the preparation. The tooth surface was then leveled with a separating disc and smoothed with 600-grit abrasive paper under running water for 25 strokes over 30 seconds (Figure 1B).<sup>17</sup>



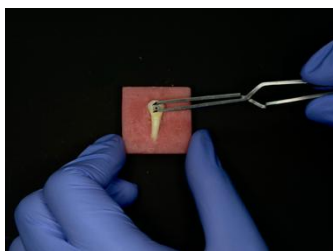
**Figure 1.** A. Embedding tooth samples in cold-cure acrylic using a mold; B. Preparation of tooth samples

In groups IA and IIA, 0.1 mL of 37% phosphoric acid (Scotchbond™ Etchant, 3M ESPE, St. Paul, MN, USA) was applied to the dentin surface using a micropipette, evenly distributed with a microbrush, and left undisturbed for 10 seconds. The surface was then rinsed with 15 mL of distilled water using a disposable syringe and gently blot-dried to a moist condition with a damp cotton pellet. In groups IA, IIA, IB, and IIB, 0.1 mL of universal adhesive (Scotchbond™ Universal Adhesive, 3M ESPE, St. Paul, MN, USA) was applied using a microbrush with a micropipette.

The adhesive was actively agitated for 15 seconds under a standardized pressure of 3 g, equivalent to horizontal contact (0° angle) with the dentin surface. The adhesive was left for 10 seconds, followed by air-drying using an air syringe at maximum pressure for 5 seconds at a distance of 10 cm and an angle of 45° to the dentin surface. Light curing was performed for 10 seconds through a single layer of celluloid strip, positioned perpendicular to the prepared surface.

The cementation procedure was performed by first inserting a composite resin syringe into the composite warmer (Ena Heat, Micerium S.p.A, Avegno, Liguria, Italy) and heating it at a temperature of 55°C for 20 minutes. Groups IA and IB were cemented using preheated microhybrid composite resin while groups IIA and IIB used preheated nanohybrid composite resin. The composite was applied using a plastic filling instrument to the intaglio surface of the lithium disilicate disc. The surface was leveled using a cement stopper. The working time of the cementation material was 30 seconds.

Lithium disilicate was placed on the dentin surface with a bracket holder applying a load of 200 g and maintained for 15 seconds. Excess cement was cleaned using a plastic instrument. The cement was immediately photopolymerized perpendicular to the lithium disilicate surface for 40 seconds using an LED curing light (Woodpecker LED Curing Light, Guilin Woodpecker Medical Instrument Co., Ltd., Guilin, Guangxi, China) (Figure 2)



**Figure 2.** Lithium disilicate disk placed on the surface of the tooth sample

The research samples were immersed in artificial saliva with pH 6.8 at 37°C for 24 hours. The artificial saliva used was made based on the Afnor method<sup>36</sup> containing Na<sub>2</sub>HPO<sub>4</sub>, KSCN, NaCl, KH<sub>2</sub>PO<sub>4</sub>, KCl, and NaHCO<sub>3</sub>. The pH of the artificial saliva was adjusted using HCl until it reached pH 6.8.<sup>18</sup> The shear bond strength (SBS) test was performed using a Universal Testing Machine (Tensilon RTF-2350, A&D Company, Limited, Tokyo, Japan) at a speed of 0.5 mm/min (Figure 3) until debonding occurred. The maximum force (N) was then divided by the bonding surface area (mm<sup>2</sup>) of the lithium disilicate restoration to calculate the shear bond strength, expressed in megapascals (MPa). The samples were then observed under a stereomicroscope (Olympus SzX7, Olympus Corporation, Tokyo, Japan) with 20x magnification to assess the type of adhesion failure.



**Figure 3.** Shear strength test using a *Universal Testing Machine*

Statistical analysis was performed using SPSS software version 26.0 for Windows (IBM Corp., Armonk, NY, USA). The shear bond strength data obtained in this study were ratio scale data. Normality was assessed using the Shaphiro-Wilk test, and homogeneity of variance was evaluated using Levene's test. The results confirmed that the data were normally distributed and homogeneous, thus meeting the assumptions for parametric testing. A two-way ANOVA was conducted, followed by a post hoc Least Significant Difference (LSD) test to determine pairwise differences in shear bond strength among the groups, with a 95% confidence level ( $\alpha=0,05$ ).

## RESULTS

The results of the shear bond strength test were measured using a universal testing machine and the shear bond strength results were obtained in megapascals (MPa). The average shear bond strength values of each group are presented in Table 1. Table 1 shows the mean and standard deviation of the shear bond strength of lithium disilicate in each treatment group. In both groups, the teeth treated with total-etch adhesives demonstrated higher SBS (Microhybrid: 14.03 ± 0.12 MPa, Nanohybrid: 12.99 ± 0.09 MPa) compared to the self-etch adhesive treated samples (Microhybrid: 13.67 ± 0.18 MPa, Nanohybrid: 10.21 ± 0.22 MPa).

**Table 1. Mean and standard deviation of the shear bond strength of lithium disilicate according to adhesive application technique and type of preheated composite resin**

Preheated Composite Resin Types	Shear Strength (MPa)	
	(A) Total-etch	(B) Self-etch
(I) Microhybrid	14.03 ± 0.12	13.67 ± 0.18
(II) Nanohybrid	12.99 ± 0.09	10.21 ± 0.22

The normality test with the Shapiro-Wilk test and the homogeneity test with the Levene test were conducted to observe whether the data were normally distributed and whether the data distribution was homogeneous. The results of the Shapiro-Wilk test and Levene test are presented in Table 2. The normality and homogeneity tests demonstrated no significant difference among the groups ( $p>0.05$ ), which indicates that the data were normally distributed with homogeneous variance. A two-way ANOVA test was then conducted to determine whether there was a significant difference in the adhesive application technique and the type of preheated composite resin on the shear bond strength of lithium disilicate.

**Table 2. Results of the normality test and homogeneity test**

No	Group	P	
		Shapiro-Wilk	Levene Test
1.	IA (preheated microhybrid; total-etch)	0.82	0.18
2.	IB (preheated microhybrid; self-etch)	0.65	
3.	IIA (preheated nanohybrid; total-etch)	0.47	
4.	IIB (preheated nanohybrid; self-etch)	0.84	

The results of the two-way ANOVA test are presented in Table 3. The two-way ANOVA test showed a significant difference between the total-etch and self-etch adhesive application techniques ( $p=0.001$ ), and between the different composite resin materials ( $p=0.001$ ), as well as a significant interaction between the adhesive material and the adhesive application technique on the shear bond strength of lithium disilicate ( $p=0.001$ ).

**Table 3. Two-way ANOVA test results**

No	Variable	Degrees of Freedom	Square Mean	F	p
1.	Adhesive material	1	35.46	1353.46	0.001*
2.	Adhesive application technique	1	17.29	660.13	0.001*
3.	Interaction between the adhesive material and the adhesive application technique	1	10.38	396.45	0.001*

Description:

F : F count/ value from the two-way ANOVA

p : Significance

\* : Significant ( $p<0,05$ )

The pairwise comparisons were performed using the Post Hoc LSD test (Table 4). The Post Hoc analysis showed significant difference between all groups ( $p=0.001$ ).

**Table 4. Post Hoc LSD test results**

Treatment Group Pairs	Mean Difference	p
IA-IB	0.35	0.001*
IA-IIA	1.03	0.001*
IA-IIB	3.82	0.001*
IB-IIA	0.67	0.001*
IB-IIB	3.46	0.001*
IIA-IIB	2.79	0.001*

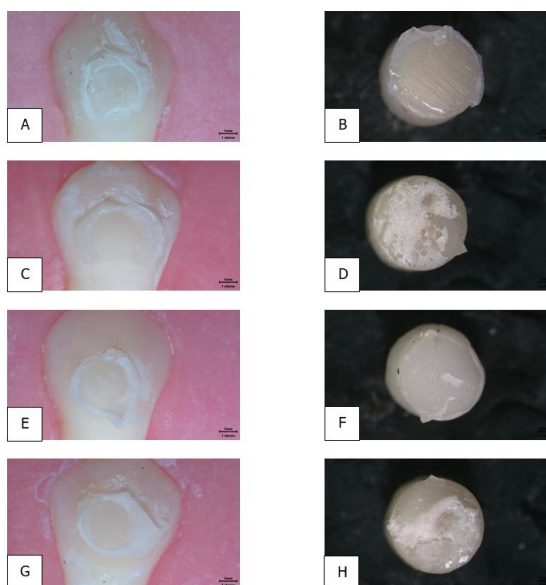
Description:

Group IA : Preheated microhybrid composite resin; total-etch

Group IB : Preheated microhybrid composite resin; self-etch

Group IIA : Preheated nanohybrid composite resin; total-etch  
 Group IIB : Preheated nanohybrid composite resin; self-etch  
 p : Significance  
 \* : Significant ( $p < 0.05$ )

The type of adhesion failure in each treatment group is presented in Figures 4A-H and Table 5.



**Figure 4.** Type of adhesion failure between the tooth surface and lithium disilicate surface A,B Group IA experienced type 3 failure; C,D Group IB experienced type 3 failure; E,F Group IIA experienced type 3 failure, and G,H Group IIB experienced type 3 failure

**Table 5. Results of adhesion failure**

Group	Adhesion Failure	Amount	Percentage (%)
Group IA	Adhesive failure	1	14.29
	Cohesive failure	0	0
	Combination failure	6	85.71
Group IB	Adhesive failure	2	28.57
	Cohesive failure	0	0
	Combination failure	5	71.43
Group IIA	Adhesive failure	3	42.86
	Cohesive failure	0	0
	Combination failure	4	57.14
Group IIB	Adhesive failure	2	28.29
	Cohesive failure	0	0
	Combination failure	5	71.43

Group IA, IB, IIA, and IIB the failures that occurred were type 3 failures, representing a combination of adhesive and cohesive failures between the adhesive material and the tooth surface and some samples experienced type 1 adhesive failure, namely failure between the resin cement and the tooth surface.

### DISCUSSION

Based on the results of the study and statistical analysis, the shear bond strength of various cementation materials to indirect lithium disilicate restorations was evaluated. The highest average values were observed in the following sequence, preheated microhybrid composite resin with total-etch, preheated microhybrid composite resin with self-etch, preheated nanohybrid composite resin with total-etch, and preheated nanohybrid composite resin with self-etch. All hypotheses were accepted. Both the type of preheated composite resin and the

adhesive technique significantly affected shear bond strength, with a significant interaction between the two factors.

Lithium disilicate is a ceramic restoration material that not only has good aesthetics and translucency but also good strength and wear resistance.<sup>3</sup> The most important factors that influence the selection of cementation materials are film thickness, marginal density, stain resistance, ability to withstand long-term functional loads, and curing ability.<sup>19</sup> The film thickness of a material is greatly influenced by viscosity, which in turn is affected by the composition of the material. Another important factor that influences the clinical success of an indirect restoration lies in the adhesive material protocol used.<sup>20</sup>

Microhybrid composite resin contains an organic matrix in the form of bisphenol A-glycidyl methacrylate (Bis-GMA), urethane dimethacrylate (UDMA) and ethoxylated bisphenol A dimethacrylate (Bis-EMA), a particle size of 0.01-3.5  $\mu\text{m}$  with a weight of 78% and a volume of 60% while nanohybrid composite resin contains an organic matrix in the form of Bis-GMA, UDMA, Bis-EMA, polyethylene glycol dimethacrylate (PEGDMA) and triethylene glycol dimethacrylate (TEGDMA), a particle size of 3  $\mu\text{m}$  or smaller and surface-modified particle silica non-agglomerated/non-aggregated 20 nm with a weight of 82% and a volume of 68%.<sup>21,22</sup>

In this study, the group with preheated microhybrid composite resin produced a higher mean shear bond strength compared to the preheated nanohybrid composite resin group. This outcome aligns with evidence from Singh et al., who observed that microhybrid composite exhibited higher shear bond strength ( $20.02 \pm 1.07$  MPa) compared to nanohybrid materials ( $18.97 \pm 1.73$  MPa), attributable to differences in filler characteristics that influence mechanical performance.<sup>23</sup> The difference in organic matrix composition was found in the type of preheated composite resin used, namely PEGDMA which replaced most of the TEGDMA monomers in the preheated nanohybrid composite resin. This replacement has an impact on increasing the viscosity of the material because PEGDMA has a higher molecular weight than TEGDMA, which produces longer and more branched resin molecules. When the composite resin is heated, the thermal energy received is sufficient to temporarily break the hydrogen bonds in the resin matrix. The molecules in the resin matrix gain additional kinetic energy so that molecular vibrations and molecular diffusion occur. Molecules with smaller molecular weights will move more easily between larger resin molecules. This increases intermolecular interactions and resistance to flow and causes higher viscosity.<sup>24</sup>

Preheated microhybrid composite resin can reduce film thickness by 30% and preheated nanohybrid composite resin reduces film thickness by 25%. This happens because preheating increases the flowability of the composite resin, so the material becomes easier to spread and produces a thinner layer when applied to the tooth surface.<sup>25</sup> Heat will cause thermal vibrations that increase molecular mobility by increasing the separation between molecules, which will increase the flowability of the composite resin.<sup>26</sup>

Another factor that affects viscosity is the volume of filler contained in the composite resin. Filler volume affects viscosity more than filler weight because, with the same filler volume, composite resin with a smaller filler particle size will have more particles in the same volume unit. As a result, the contact surface area between filler particles becomes larger, which increases the interaction between filler particles and the resin matrix, as well as between filler particles themselves. This causes an increase in viscosity. Preheated microhybrid composite resin has larger filler particles and a more heterogeneous particle size distribution, resulting in lower viscosity after preheating.<sup>27</sup>

The lower viscosity of preheated microhybrid composite resin can increase resin penetration into the microscopic structure of dentin and lithium disilicate, resulting in better interaction between the resin and the substrate. Previous studies have shown that increased viscosity and stable dimensions in composite

resins with larger fillers can produce stronger and more stable bonds than resins with smaller particle sizes.<sup>10</sup>

Fillers in composite resins are non-reactive to temperature (isothermal), meaning that fillers do not provide substantial thermal reactions even when the temperature increases. The higher the filler content in the composite resin, the greater the resistance to the free flow of the resin because the filler does not play a role in reducing viscosity when the resin is heated. Fillers act as components that inhibit the movement of resin molecules, so even if the temperature of the composite resin is increased through preheating, the increase in temperature will not significantly reduce the viscosity. Higher filler content in preheated nanohybrid composite resins showed increased viscosity.<sup>28</sup>

In this study, the group with preheated nanohybrid composite resin produced a lower average shear bond strength because fillers that are larger than the interfibrillar spaces in etched dentin (15-20 nm) can accumulate on the dentin surface, inhibiting the penetration of cementation materials. This phenomenon has been documented in dental adhesive systems, where the addition of fillers larger than the interfibrillar spaces increased viscosity and led to reduced adhesive penetration into dentin, which could compromise bond strength. This is consistent with the study conducted by Fallahzadeh et al., in which the accumulation of oversized fillers on the etched dentin surface was associated with the formation of a defective hybrid layer and decreased bond performance.<sup>29</sup> In addition, the role of nanofillers on shear strength is also influenced by the amount of filler, the more nanofiller content in the resin, the greater the possibility of cluster formation. The formation of larger nanofiller clusters within the interfibrillar space can accumulate on the etched dentin and reduce the shear strength.<sup>30</sup>

In this study, the group with the total-etch adhesive application technique produced a higher average shear bond strength compared to the self-etch technique group. This finding is supported by several studies, for instance, Manzoor et al., reported that the shear bond strength of total-etch adhesives ( $18.34 \pm 2.87$  MPa) was significantly higher than that of self-etch adhesives ( $16.21 \pm 3.05$  MPa) on permanent dentin, highlighting the advantage of more complete etching and deeper resin infiltration.<sup>31</sup> The higher shear bond strength in the total-etch application technique group can be attributed to the etching procedure that forms more irregularities on the tooth surface. The total-etch application technique using 37% phosphoric acid can demineralize dentin to a depth of 7.5  $\mu\text{m}$ .<sup>32</sup> Phosphoric acid causes dentin demineralization and removal of the smear layer, which exposes collagen fibrils. The smear layer acts as a physical barrier to the penetration of adhesive monomers, and the use of phosphoric acid helps increase the impregnation of monomers into dentin. Phosphoric acid causes hydroxyapatite to degrade and produces calcium monophosphate compounds that dissolve after being rinsed with water.

This process would increase the surface energy and surface-wetting ability of the dentin, thereby increasing the adhesive strength between the dentin and the composite resin material. The adhesive bonding mechanism is based on the demineralization of the superficial layer followed by the infiltration of resin monomers. After polymerization, the monomers form strong micromechanical bonds. This process is known as hybridization of the dentin surface, which is characterized by the formation of a hybrid layer consisting of collagen fibrils infiltrated by resin monomers.<sup>33</sup>

The adhesive material used in this study contains polyalkenoic acid copolymer (PAC) which can form chemical bonds with hydroxyapatite in dentin. The presence of PAC allows chemical bonds to occur, which increase the bond strength between the adhesive material and the teeth. The role of PAC is more significant in the total-etch technique than in self-etch. Polyalkenoic acid copolymer (PAC) functions to bind the remaining hydroxyapatite, making a major contribution to strengthening the chemical bond.<sup>34</sup>

The lower shear bond strength in the self-etch technique is due to differences in the formation of the hybrid layer. The self-etch technique combines phosphoric acid etchant and bonding material/primer in one package. The combination of the two materials can cause weak penetration of the acidic primer into the enamel because the phosphate and calcium produced from the dissolution of hydroxyapatite crystals will combine with the primer solution. This reduces the effectiveness of etching because the high concentration of calcium and phosphate ions in the adhesive solution can limit the dissolution of hydroxyapatite, thereby reducing the depth of demineralization in dentin. The acid in the monomer will dissolve the hydroxyapatite on the dentin surface to a depth of 1  $\mu\text{m}$ . As a result, the penetration of the adhesive material into the dentin structure is less than optimal, so the hybrid layer formed is thinner. The thickness of the hybrid layer affects the shear bond strength, whereas a thinner hybrid layer can reduce the adhesion strength and stability of the restoration.<sup>16</sup>

Preheated composite resin can be a challenge because the cementation process must be carried out quickly, as there is a temperature drop of 50% after 2 minutes when the resin material is removed from the preheating device.<sup>3</sup> Winarta et al. (2020) suggest that, to avoid a decrease in temperature, the composite heater can be placed as close as possible. Composite resin as a cementation material has several advantages over resin cement, such as lower prices, more diverse color choices, and better mechanical properties.<sup>35</sup>

The limitation of this study is its in vitro design, which may not fully represent clinical conditions. Bond strength was evaluated only after 24 hours, thereby limiting the findings to short-term performance. Furthermore, the use of a shear bond strength test, a limited sample size, and the inclusion of only maxillary premolars restrict the generalizability of the results.

## CONCLUSION

Both the type of composite resin and the adhesive application technique significantly influence the shear bond strength between tooth structure and lithium disilicate. Preheated composite resin showed higher shear bond strength when used with total-etch adhesives compared to self-etch adhesives, with microhybrid composites combined with total-etch adhesives exhibiting the highest bond strength.

The implication of these findings is that both the choice of adhesive application technique and the type of preheated composite resin significantly influence the shear bond strength to lithium disilicate, suggesting that optimizing these factors, particularly using the total-etch technique combined with preheated microhybrid composite resin, can enhance the clinical performance and durability of adhesive restorations.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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