ORIGINAL ARTICLE

Journal of Emergency Health Care. 2025;14(1): 45
https://doi.org/10.22034/jehc.14.1.45

Effects of Different Adhesive Systems on the Bond Strength of Repaired Bulk-Fill Composites

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Article history:

Received: 13 Apr 2025
Accepted: 20 Sep 2025
Available online: 28 Sep 2025

Keywords:

Bulk-fill composite
Adhesive system
Bond strength
Repaired composite
Shear bond strength
Dental composite

Abstract

Objectives: In most cases, the repair of existing dental restorations is preferred to changing the whole restoration. We designed a study to evaluate the effect of elective bonding systems on the result of bulk-fill composite repairs, which seems to be essential.
Materials and methods: Fifty-four samples of two types of bulk-fill composites: X-tra fil dental Bulk-fill composite and Tetric EvoCeram Bulk Fill composite, and three types of adhesive bonding 3M ESPE Scotchbond universal adhesive, G-Premio Bond, and ClearFil SE Bond, were used. The composite samples were placed in the mold, flattened by a glass slab, and then light-cured. The samples were stored in distilled water. Then they were thermocycled. The samples were divided into six groups (n = 9), and each composite was repaired with the same composite and different adhesive systems. The prepared samples were stored in distilled water once more. Then, the shear bond strength test was established using the universal test machine with a loading speed of 0.5 mm/min. The statistical data analysis was done with SPSS 17 software. ($p<0.05$)
Results: The results of the samples' independent T-test showed that there is no statistically significant difference between the mean bond strength of the two types of Bulk-Fill composites (p-value > 0.05). In addition, the results of the one-way ANOVA test showed that there is no statistically significant difference between the mean bond strengths of the three types of adhesive systems (p-value > 0.05).
Conclusions: In conclusion, the type of adhesive used has no significant effect on the repaired bulk-fill composite bond strength. Also, the type of bulk-fill composite has no significant effect on the bond strength.

Cite this article as: Talebabbasi F, Rezaei Y, Daneshpooy M, Ghasemi S. Effects of Different Adhesive Systems on the Bond Strength of Repaired Bulk-Fill Composites. 2025;14(1):45. https://doi.org/10.22034/jehc.14.1.45.

Introduction

In recent years, tooth-colored composite resin materials have gained wide popularity. This popularity is attributed to the non-invasive preparation technique and improved adhesion to tooth structures [1]. However, failures and fractures of these restorations can still occur, resulting in repairs to the restoration [2].

Failed restorations are commonly replaced, even though replacement procedures can lead to excessive removal of the sound tooth, weaken the tooth structure, and sometimes lead to pulp exposure. To avoid these

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complications, it is preferable to repair the restorations instead of replacing them [3]. Restorations with minor damage—small fractures, signs of absence of marginal infiltration, and secondary caries—may be repaired. As aged restorations do not contain an unpolymerized surface layer, several techniques are suggested to improve the composite–composite bond [4]. This attachment could be provided micro- or macro-mechanically and chemically by surface treatment protocols such as diamond bur preparation, sandblasting with aluminium oxide particles, phosphoric or hydrofluoric acid etching, laser irradiations, and the use of intermediate bonding agents [5]. The application of silane to the composite was suggested to improve the wettability of the fillers on the composite surface and consequently the adhesion of the composite [6]. Whereas the bonding agents make a micromechanical retention by penetrating the matrix and creating a chemical bond between two components. Although there is much in vitro research about strategies of repair, there is no agreement on an accurate guideline for the repair process [7].

There is a controversy among studies about the effect of using silane. Some claim that using a silane-based adhesive may give the best outcome in terms of enhancing bond strength. In contrast, the others claim that there are no significant differences in bond strength values among different adhesion protocols. Some studies recommended further studies to overcome the controversies [8, 9].

The demand for a true amalgam alternative for posterior teeth restorations kept on increasing. Thus, the clinical use of bulk-fill resin composites as a restorative material for posterior teeth has increased because of the advantages and ease of use. As a result, there is a considerably increasing in cases of repairing aged restorations [10-12]. Despite many studies on the repair bond strength of dental composites [13], no studies have been done about repairing bulk-fill composites with new adhesive systems. Recently, the 8th generation of dental bondings, or universal type, has been introduced, and according to the company's claim, they are more effective in repairing cases because of their silane. Since no studies have evaluated the effect of selected bonding systems on the result of repairing bulk-fill composites, this study aimed to evaluate the effects of different adhesive systems on the bond strength of repaired bulk-fill composites.

Material and Method

This study was approved by the Research and Ethics Committee of Tabriz University of Medical Sciences [14], and the approval number by the Bioethics Committee is IR.TBZMED.VCR.REC.1398.131 . Two bulk-fill composite resins and three bonding agents were selected for this investigation: X-tra Fil Bulk Fill Packable Posterior Composite [VOCO/Germany] and Tetric EvoCeram Bulk Fill [Ivoclar Vivadent], 3M Scotchbond [3M], G-Premio Bond [GC], and ClearFil SE Bond [Kuraray]. (Table.1)

Table 1: Experimental Groups

Composite Resin	Bonding Agent
Tetric EvoCeram Bulk Fill [Ivoclar Vivadent]	G-Premio Bond [GC] 3M Scotchbond [3M] ClearFil SE Bond [Kuraray]
X-tra Fil Bulk Fill Packable Posterior Composite [VOCO/Germany]	G-Premio Bond [GC] 3M Scotchbond [3M] ClearFil SE Bond [Kuraray]

Three groups of nine rectangular specimens of each composite were made in a split mold. To assure flat specimen sides, the bottom surface of the mold was covered with a glass slab. Each increment was flattened by a glass slab before polymerization. The substrates were light polymerized with an LED hand light curing device [Optilux-501, Kerr, CT, USA] for 40 s. The light intensity unit was 800 mW/cm2 and verified before and after curing by a radiometer [Optilux Radiometer Model-100 SDS Kerr, Danbury, CT, USA]. After curing was completed, the specimens were removed from the mold and stored in distilled water at 23 °C for two weeks. Then, it thermocycled for 1000 cycles between 5 and 55 °C with a dwell time of 30 s at each temperature and a transfer time of 10 s before testing. After that, the 54 specimens were drawn and divided into six groups, each containing nine specimens.

Group one, consisted of EvoCeram Bulk Fill composite samples, in which the surface was coated with a layer of the G-Premio Bond [GC] adhesive system by a micro brush and thinned with an air spray. After waiting for 20 s, they light-cured for 20 s. Then added a new layer to create repaired specimens using the same brand of composite [EvoCeram Bulk Fill composite], and light cured them for 40 s.

Group two, consisted of EvoCeram Bulk Fill composite samples in which the surface was coated with a layer of 3M Scotchbond [3M] adhesive system by a micro brush, and thinned with an air spray. After waiting for twenty seconds, it was light-cured for 20 s. Then added a new layer to create repaired specimens using the same brand of composite. Then added a new layer to create repaired specimens using the same brand of composite [EvoCeram Bulk Fill composite], and light cured for 40 s.

Group three, consisted of EvoCeram Bulk Fill composite samples, in which the surface was coated with a layer of ClearFil SE Bond adhesive system by a micro brush and thinned with an air spray. After waiting for 20 s, for another 20 s it was light-cured. Then added a new layer to create repaired specimens using the same

[DOI: 10.22034/jehc.14.1.45]

brand of composite [EvoCeram Bulk Fill composite] and light-cured them for 40 s.

Group four, consisted of X-tra Fil Bulk Fill composite samples, in which the surface was coated with a layer of the G-Premio Bond [GC] adhesive system by a micro brush and thinned with an air spray. After waiting for twenty seconds, for another 20 s it was light-cured. Then added a new layer to create repaired specimens using the same brand of composite [X-tra Fil Bulk Fill composite] and light-cured them for 40 s.

Group five, consisted of X-tra Fil Bulk Fill composite samples, in which the surface was coated with a layer of the 3M Scotchbond [3M] adhesive system by a micro brush and thinned with an air spray. After waiting for 20 s, it was light-cured for 20 s. Then added a new layer to create repaired specimens using the same brand of composite [X-tra Fil Bulk Fill composite] and light-cured them for 40 s.

Group six, consisted of X-tra Fil Bulk Fill composite samples, in which the surface was coated with a layer of ClearFil SE Bond adhesive system by a micro brush and thinned with an air spray. After waiting for 20 s, they were light-cured for 20 s. Then added a new layer to create repaired specimens using the same brand of composite [X-tra Fil Bulk Fill composite] and light-cured them for 40 s.

Each of the specimens was transferred to separate bottles containing distilled water and stored for another two weeks at 37 °C.

After the specimens had been removed from the distilled water bottles, they have been mounted in an acrylic resin box from the bonding area. The old composite was completely mounted in the acrylic resin box, and the new composite was placed over the acrylic resin surface. In this way, the bonded material combination was exactly at the interface of two composites. Then, a shear bond strength test was performed using a universal testing machine [Hounsfield H5KS], with which the load was continuously registered at the interface of the substrate and adhesive resin at 0.5 mm/min cross-head speed until fracture.

Statistical Analysis

Statistical analysis was performed using SPSS software [SPSS version 17.0, Chicago, IL, USA]. To evaluate the data's normality, the KS test was used. A one-way ANOVA test was used to compare the shear bond strength values for all adhesives. The One-sample T-test was used to compare the shear bond strength in two different composites. The level of significance was set at 0.05.

Result

According to the shear bond strength absolute results (Table.2), and the results of the Two-way ANOVA test, there was no statistically significant difference among the three types of adhesive systems regarding the mean shear bond strength ($p > 0.05$).

Table 2: The shear bond strength results of each specimen in MPa (Mega Pascal)

Group	Specimen 1	Specimen 2	Specimen 3	Specimen 4	Specimen 5	Specimen 6	Specimen 7	Specimen 8	Specimen 9
1	24.5750	29.5250	34.4750	39.4250	44.3750	49.3250	53.5750	57.8250	62.7750
2	28.4075	32.4275	36.4475	40.4675	44.4875	48.5075	52.5275	56.5475	60.5675
3	34.3556	39.8556	45.3556	50.8556	56.3556	61.8556	67.3556	72.8556	78.3556
4	11.4875	18.9875	26.4875	33.9875	41.4875	48.9875	56.4875	63.9875	71.4875
5	13.7556	25.0056	36.2556	47.5056	58.7556	70.0056	81.2556	92.5056	103.7556
6	52.9333	54.0833	55.2333	56.3833	57.5333	58.6833	59.8333	60.9833	62.1333

Table 3: The mean shear bond strength values and standard deviations of all tested groups in MPa (Mega Pascal)

Bonding Agents	Composite Resin	Mean	Standard Deviation
ClearFil SE Bond [Kuraray]	Ivoclar	56.3556	14.2009
	VOCO	57.5333	2.96927
3M Scotchbond [3M]	Ivoclar	44.4875	10.37959
	VOCO	58.7556	29.04866
G-Premio Bond [GC]	Ivoclar	44.3750	12.78084
	VOCO	41.4875	19.36491

Also, the difference was not statistically significant between the two types of bulk-fill composites regarding the mean shear bond strength ($p > 0.05$). Furthermore, there was no mutual effect between the adhesive system type and the composite type. In another way, three adhesive system types have a similar effect on the mean

[DOI: 10.22034/jehc.14.1.45]

shear bond strength value in two different composite types (p 0/05). (Fig. 1)

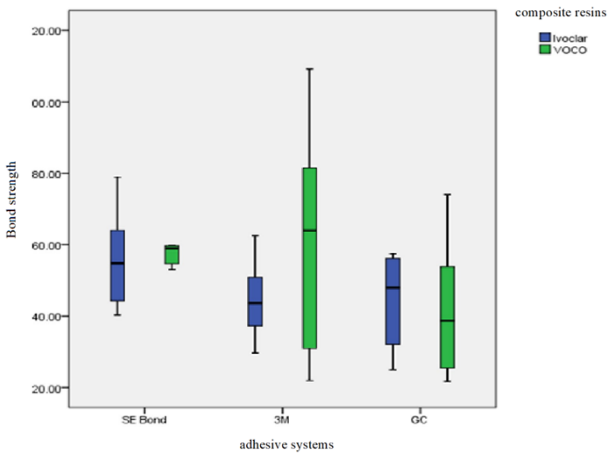

Fig. 1: Bond strength variable in different adhesive systems and different composite resins

Discussion

The results of the present study showed that the adhesive system type does not have a significant effect on the bond strength of repaired bulk-fill composites. Also, the type of bulk-fill composite has no significant effect on the bond strength. Kamble et al. evaluated and compared the tensile bond strengths of 6th, 7th, and 8th-generation dentin adhesives. They used bonding agent-Adper SE plus 3M ESPE as the 6th generation, bonding agent G Bond GC as the 7th generation, and dentin adhesives-FuturaBond, DC, and Voco as the 8th generation. The result was that 8th-generation dentin adhesives showed better tensile bond strength compared to 6th and 7th-generation dentin bonding agents and appeared to be more advantageous. Also, the 7th generation bonding agent showed the lowest bond strength compared to the 6th generation [15]. The purpose of the Basaran et al. study was to determine and compare the shear bond strength of a recently developed modification of the self-etching adhesive system with another self-etching adhesive system and a conventional acid etching system. In this study, three self-etching products Adper Prompt L-Pop, Futurabond NR, and Transbond Plus and a conventional 38 percent phosphoric acid etching system were used. They concluded that the differences in shear bond strength of self-etching products were not significantly different. Although self-etching primer adhesive systems revealed higher bond strengths than conventional ones [16], Nikhil et al. evaluated the effect of 2-hydroxymethyl methacrylate (HEMA) and the type of solvent on the tensile bond strength of the following three self-etch adhesives: Adper Easy One (HEMA-rich adhesive), which contained ethanol; G-Bond (HEMA-free adhesive), which contained acetone; and Xeno V (HEMA-free adhesive), which contained butanol as a solvent. This study revealed that the bond strength of ethanol-based HEMA-rich self-etch adhesive is better than HEMA-free self-etch adhesive that contains acetone and butanol as solvents [17]. The Yaseen et al. study was undertaken to evaluate and compare the shear bond strength of two self-etching adhesives (sixth and seventh generation) on the dentin of primary and permanent teeth. They used Contax for the sixth generation and Clearfil S3 for the seventh generation bondings. The result demonstrated that permanent teeth bonded with Clearfil S3 showed more shear bond strength than the primary teeth bonded with Contax [18]. In 2007, a study was done by Cavalcanti et al. to evaluate the effect of bonding procedures and surface treatments on the bond strength of composite repairment. The specimens were allocated into 12 groups (N = 10) according to the combination of bonding procedures, and the surface treatment. There was no difference of the repair bond strength in groups with different combinations of surface treatments and bonding procedures (19). In contrast, in this study, the surface treatment variable was used. Additionally, in this study, the 3M Co. fifth-generation bondings and the Kuraray Co. sixth-generation bondings were used. Although in the present study the GC Co. eighth-generation bondings, the 3M Co. seventh-generation bondings, and the Kuraray Co. sixth-generation bondings have been used, Despite these differences, the results of this study are similar to the present study. Also, Oglakci et al. evaluated the shear bond strength of repaired high-viscosity bulk-fill resin composites with different adhesive systems: Clearfil SE Bond and Single Bond 2. They concluded that there were no significant differences in the shear bond strength according to the type of adhesive systems for both repair materials [7]. In this study, the Kuraray Co. sixth-generation bondings and the 3M Co. fifth-generation bondings were used. Whereas, in the present study, the GC Co. eighth-generation bondings, the 3M Co. seventh-generation bondings, and the Kuraray Co. sixth-generation bondings have been used. Despite these differences, the two studies have demonstrated similar results. Xiong et al. evaluated the effect of NaOCl conditioning on the shear bond strength of resin-bonded dentin with three total-etching adhesive systems: One Step Plus, Prime and Bond, and Single Bond. The result was that no statistical differences were shown among the three adhesive systems when the dentin surface was treated with phosphoric acid, though the highest bond strength was obtained with a Single bond [20]. In this study, the OS, Bisco Co. fifth generation bondings, PB, Dentsply Caulk Co. fifth generation bondings, and 3M Co. fifth generation bondings have been used. In the present

[DOI: 10.22034/jehc.14.1.45]

study, different types of bondings were used, so the reason for the different study results may be the different types of bondings. In a study, Fornazari et al. tried to evaluate the effect of surface treatments and universal adhesives in the nanoparticle composite repairs microshear bond strength. They concluded that there are statistically significant differences between the "surface treatment" and "adhesive" variables. Silane containing universal adhesive has a similar effect to any combination of adhesive and silane, particularly when applied on air-abraded surfaces. However, air abrasion with Al2O3 particles increased the repair bond strength of the nanoparticle composite, using MDP-containing silane does not result in a statistically significant increase in bond strength [21]. In another study, the effects of different adhesive systems on the repair bond strength of aged resin composites were evaluated. Some composite samples were built, but half of them were exposed to thermal aging procedure. All samples were repaired using three different adhesive systems: a total-etch adhesive, both the two-step, and a one-step self-etch adhesives; then they were subjected to shear forces. Aging procedure and type of adhesive affected the repair bond strengths. No difference was found in aged samples repaired with two-step adhesives. lower bond strength were found in one-step self-etch adhesive in aged samples [22]. In another study, A. Tezregil demonstrated a somewhat similar result and concluded that multi-step adhesion primers yielded higher bond strengths compared to one-step primers or intermediate resins [2]. This finding is in contrast with the results of the present study. The reason for this contrast may be the different adhesive system types and different aging conditions. Furthermore, Loomans, in a study assessing the effect of various repair techniques on indirect restorations, demonstrated that the effect of surface treatment procedures on the repair bond strength of indirect composites depends on the substrate and aging [23]. Whereas, in the Shahdad study, which evaluated the bond strength of repaired anterior composite resins, it was concluded that although there were some differences in the bond strength over the time of the study, none of these were statistically significant [24]. Another result that was demonstrated in the present study with an independent T-test was that the bulk-fill composite type does not affect the bond strength of repaired composite resins. In a study, the bond strength of aged resin-based nanocomposites repaired with the same and bulk fill composites was analyzed. Seventy-two disc-shaped resin composites consisting of three different nanocomposite resins (Filtek Ultimate/FU, Herculite XRV Ultra/HXRV, and Reflectys/R) were produced and divided into six groups: Filtek Ultimate+Filtek Ultimate/Group-1; Filtek Ultimate+Tetric BF/Group-2; Herculite XRV+Herculite XRV/Group-3; Herculite XRV+Tetric BF/Group-4; Reflectys+Reflectys/Group 5; Reflectys+Tetric BF/Group-6; The result showed FU and R were found to be similar, while HXRV was significantly different from them. A significant difference between groups 1 and 2 was detected, while there were no differences between groups 3 and 4, or 5 and 6 [25].

Conclusion

According to the results of this study, the adhesive system type does not have a significant effect on the bond strength of repaired bulk-fill composites. Also, the type of bulk-fill composite has no significant effect on the bond strength. Furthermore, there was no mutual effect between the adhesive system type and the composite type.

Acknowledgments

I would like to express my sincere appreciation to the Dental and Periodontal Research Center, Tabriz University of Medical Sciences, and individuals whose contributions and support have greatly enhanced the quality of this research, particularly Arefeh Heshmati in language editing, writing support, and proofreading services.

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[DOI: 10.22034/jehc.14.1.45]