

***In Vitro* Effects of Different Surface Preparation Techniques on Shear Bond Strength of Direct to Indirect Composite Resin**

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Abstract

Objective: Repair of an indirect restoration is usually preferred over its replacement. This study aimed to evaluate the effect of silane in different surface preparation techniques on the bond strength of direct to indirect composite resin.

Methods: For this *in vitro* experimental study, 48 indirect composite cubes were fabricated, divided into 4 groups of 12 and subjected to the following preparation techniques: Group 1. Sandblasting with 50 μ aluminum oxide particles (SB), Group 2. Sandblasting+ silanization (SB+Sil), Group 3. Etching with 9.5% hydrofluoric (HF) acid, Group 4. Etching with 9.5% HF acid+ silanization (HF+Sil). Before the restoration process, specimens were subjected to 500 thermal cycles and received surface preparations. Single Bond adhesive was applied to the surface in all groups. Specimens were restored with direct composite resin and stored in an incubator at 37°C for 24h. Fracture was induced in the specimens by an Instron machine and the shear bond strength was measured. Data were converted to mega Pascal and analyzed using two-way ANOVA and Tukey's post hoc.

Results: The highest shear bond strength was 13.85 (2.75) MPa and belonged to group 1; while the lowest bond strength was 8.43 (1.35) MPa and observed in group 2.

Conclusion: Based on the obtained results, composite surface preparation by sandblasting yields more favorable results than HF acid etching and application of silane can also increase the bond strength.

Key words: Dentin bonding agents, Shear bond strength, Silane, Stress, Surface preparation.

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Introduction:

Indirect dental restorations are used to overcome the shortcomings of direct techniques. Direct composite resin restorations have some drawbacks such as polymerization shrinkage and low degree of conversion (DC). Moreover, extra-oral fabrication of restorations usually results in more favorable proximal contacts, morphology and occlusal surface contour. Extra oral polymerization increases the DC and positively affects the mechanical properties of composite resins. Laboratory composites have high percentage of mineral fillers that improve

their physical and mechanical properties (1, 2). Fracture of indirect restorations in the oral cavity is a serious and costly problem encountered in dental offices and poses a challenging situation in terms of esthetics and function of the restoration for both the patient and the clinician. Partial fracture of an indirect restoration does not necessarily mean failure of the entire restoration since the restoration replacement is a timely and costly process. Intraoral repair of such cases seems to be more reasonable and is usually preferred over the restoration replacement (3).

Several preparation techniques have been

evaluated and discussed for the repair of composite restorations yielding controversial results regarding the efficacy of silane and different surface preparation techniques. Melo, *et al.* (2011) reported similar bond strength for composite resin repair following surface preparation with diamond bur, phosphoric acid, saline, adhesive and air abrasion compared to the control group. Moreover, they concluded that surface preparation with 37% phosphoric acid along with adhesive application should not be used alone for composite resin repair (4). D'Arcangelo and Vaninib in 2007 stated that composite surface preparation with adhesive, sandblasting or a combination of sandblasting and salinization yielded higher bond strength than HF acid etching followed by salinization (5). Bonstein *et al.* (2005) evaluated different repair protocols for aged composite restorations using 5 surface preparation techniques and concluded that surface preparation with bur and air abrasion created the highest bond strength (6). Ikeda *et al.* in 2005 attributed the highest shear bond strength to sandblasting and reported that etching provided lower bond strength (7). In another study by Trajtenberg and Powers (2004) on the bond strength of laboratory composites repaired by 3 surface preparation techniques, it was concluded that 8% HF acid used with ArtGlass composite, resin and silane primer yielded the highest bond strength (8). This study aimed to assess the effect of different surface preparation techniques on the shear bond strength of direct to indirect composite resin under in vitro conditions.

Methods:

This in vitro, experimental, interventional study was conducted on 48 composite specimens that based on the type of surface preparation were divided into 4 groups of 12. Transparent molds measuring 5×5×10mm were used for the fabrication of base specimens. Molds measuring

3mm in height and 2.5mm in diameter were used for the fabrication of repair samples (Figure 1). Larger molds were filled with ArtGlass indirect composite resin (Heraeus-Kulzer-Jelenko, Armonk, NY; 800043101785) and light cured for 20s using GC light curing unit (GC Step light SL-1 Corp., Tokyo, Japan) (10s from the top and 10s from beneath). Specimens were then placed in a furnace (Labo light LV-III, GC Corp., Tokyo, Japan for 3min to allow post curing. Next, specimens were subjected to 500 thermal cycles (Vafaei, Tehran, Iran) between 5-55°C, 1min in each bath and 10s of dwell time to simulate oral conditions (9).



Figure 1- Indirect composite block and direct composite mold

In group 1, air abrasion (Dento-Prep TM, RØNVIG A/S, Daugaard, Denmark) was carried out for 10s using 50μ aluminum oxide particles at 5bar and 70 psi pressure with the tip of device at 5cm distance from the specimen surface and perpendicular to it in order to whiten the surface. In group 2, specimens were etched with 9.5% HF acid (Ultradent Product, South Jordan, UT 84095, USA) for 1min, rinsed for 30s and air dried.

In group 3, air abrasion was performed with 50μ aluminum oxide particles, silane (Ultradent Product, South Jordan, UT 84095, USA) was applied to the surface for 1min and air dried.

In group 4, 9.5% HF acid was applied to the surface for 1min, rinsed and air dried. Silane was applied to the surface, remained for 1min and air dried. Single Bond adhesive (G Bond, GC Corp.,

Tokyo, Japan) was applied to all specimen surfaces for 10s and cured for 20s using Coltolux 50 light curing unit (Coltene, Whaledent Inc.). In order to add the repair composite to the base specimen surface, transparent cylindrical plastic molds measuring 3mm in height and 2.5mm in diameter were filled with the A2 shade of Amelogen Plus composite (Ultradent Product, South Jordan, UT 84095, USA) and placed over the base specimen surface. Specimens were light cured from all directions for 40s. The transparent mold was separated using a scalpel. After repair, specimens were stored in an incubator at 37°C for 24h to allow complete polymerization. All specimens were subjected again to 500 thermal cycles (Vafaei, Tehran, Iran) between 5-55°C, 1min in each bath and 10s dwell time (9, 10). Specimens were then mounted into metal molds measuring 2x2 mm containing self-polymerizing acrylic resin in such way that 1mm of each specimen surface was out of the mold. In order

to facilitate the extraction of self-polymerizing acrylic resin cylinders from the mold, the internal surface of the mold was coated with Vaseline. The shear bond strength test was performed using an Instron machine (Dartec NCIO, England). All specimens were fixed in the device one by one. The load was applied at a cross-head speed of 0.5 mm/min. The loads were recorded in Newton. The shear bond strength was calculated in mega Pascal by dividing the load by the cross section of composite specimen (11). Data were analyzed using SPSS version 16 and the two way ANOVA and Tukey’s post hoc tset was performed for analysis.

Results:

As observed in Table 1, the mean shear bond strength was 13.85 (2.75) MPa in SB group, 8.43 (1.35) MPa in SB+Sil, 13.83 (5.35) MPa in HF and 13.15 (2.20) MPa in HF+Sil group.

Table 1-The mean and SD of shear bond strength in the 4 groups

Group	Mean	SD	Minimum	Maximum	Number
SB	13.85	2.75	9.60	18.60	12
SB+Sil	8.43	1.35	6.40	10.80	12
HF	13.83	5.35	7.00	22.40	12
HF+Sil	13.15	2.20	11.00	18.60	12

As observed in Table 2, the effect of sandblasting on the shear bond strength was statistically significant (F=6.16, p=0.017). Thus, sandblasting can significantly affect bond strength. The effect of silane in this respect was statistically significant as well (F=10.35, p=0.002). Thus, silane significantly affects bond

strength. Moreover, the interaction effect of sandblasting-silane was statistically significant (F=6.28, p=0.016). Thus, the interaction of sandblasting-silane significantly affects the bond strength. Tukey’s post hoc test was used for pair wise comparison of groups. The results are demonstrated in Table 3.

Table 2- The results of two-way ANOVA for evaluation of the effect of sandblasting and silane application on the mean bond strength in the 4 groups

	Total square	Degree of freedom	Mean square	F	p
Sandblast	66.17	1	66.17	6.16	.017
Silane	111.14	1	111.14	10.35	.002
Sandblast-silane	67.40	1	67.40	6.28	.016

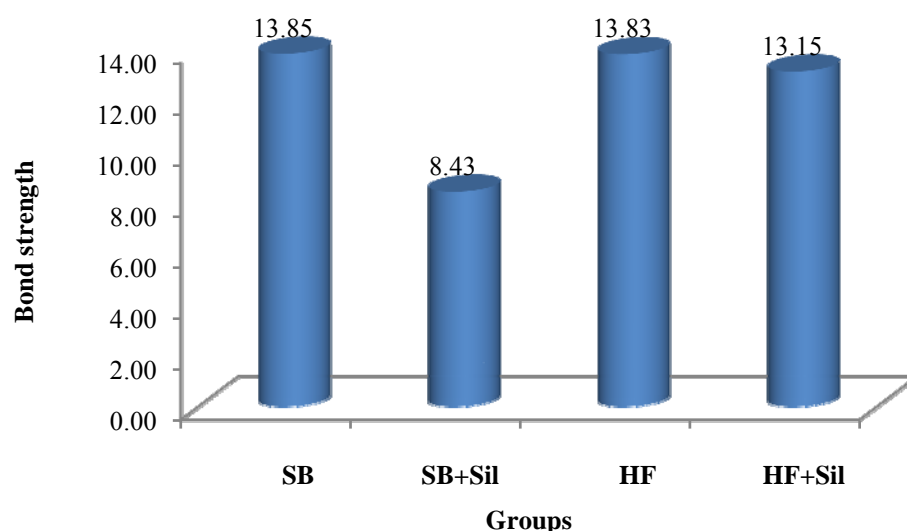
Table 3-The results of pairwise comparison of bond strength among groups by Tukey's test

Group	Mean	SB	SB+Sil	HF	HF+Sil
SB	13.85	—	5.41*	0.021	0.69
SB+Sil	8.43	—	—	-5.39*	-4.71*
HF	13.83	—	—	—	0.67
HF+Sil	13.15	—	—	—	—

*Significant

The results of Tukey's post hoc test revealed that the mean bond strength in group SB was significantly higher than in group SB+Sil but no significant difference was found between SB and HF or HF+Sil. Moreover, the differences

between SB+Sil and HF and HF+Sil were statistically significant but HF and HF+Sil were not significantly different in this respect (Diagram 1).

**Diagram 1- The mean of bond strength in the 4 groups**

Discussion:

Fracture of composite restorations in the oral cavity is a common occurrence attributed to several reasons such as development of recurrent caries along the restoration margin (with other parts being intact) or removal of a large part of the restoration (12). Such fractures do not necessitate removal of the entire restoration and its replacement; because complete replacement of a composite restoration usually requires greater removal of tooth structure to achieve maximum bond strength. Thus, repair seems to be a more reasonable solution increasing the

restoration survival and reducing patient costs. Several problems may be encountered during the repair of old indirect composite restorations. Due to the absence of air-inhibited layer, high DC and release of unreacted monomers (even in small amounts), unsaturated double bonds decrease compromising bond formation between the indirect composite restoration and the new composite (13-15). Furthermore, increased polymerization decreases the solubility and penetrability of polymer. Thus, prior to repair, the surface should be necessarily roughened to establish micromechanical bonding. Increased surface roughness enhances mechanical

interlocking and increases the odds of finding residual free carbon bonds in the superficial layer. The bond strength of composite to etched enamel has been extensively investigated and reported to be 15-30 MPa. It is well understood that composite rarely undergoes adhesive fracture at the composite-etched enamel interface. Thus, a composite repair bond similar to the composite bond to etched enamel is clinically favorable (16-18). Several protocols are available for repair of composite restorations. This study evaluated the effects of 4 different surface preparation techniques as well as silanization on the shear bond strength of a direct repair composite to ArtGlass indirect composite restorations.

ANOVA revealed significant differences in bond strength among the 4 groups ($p=0.05$). Based on the literature, increasing the surface roughness and mechanical and chemical surface preparation improve the bond strength of direct to indirect composite resins (11, 19, 20).

According to some previous studies (21, 22), sandblasting is the most suitable surface preparation technique for indirect composites because aluminum oxide particles create a uniform porous pattern and cause micromechanical retention by the penetration of monomer into matrix microcracks. This finding is in accord with our results.

Pontes *et al.* in 2005 stated that HF dissolves glass particles but provides a weak substrate for the adhesive, damages the polymer matrix, matrix interface and composite filler and decreases the bond strength. Moreover, due to the harmful effects of HF, contact with skin or oral mucosa must be avoided (21). Therefore, when using HF for repair of an indirect restoration, knowledge about the composite composition and use of rubber dam are required. In studies by Tarjtenberg and Powers (2004)(8) and D'Arcangelo and Vaninib (2007)(5), use of silane for improving bond strength was found to be effective; this finding is in agreement with

our results. Surface modifiers like silane have excellent properties for the bond of dissimilar inorganic and organic materials. Such modifiers belong to the group of hybrid organic-non-organic materials and contain direct silicon-carbon bonds. In resin-based composites, these modifiers play a role in filler surface modification as a surface bonding agent for composite-composite bond and provide a durable chemical bond between them (5).

In contrast to our study, Cho *et al.* in 2013 (15) and Celik *et al.* in 2011 (23) reported that silane had no significant effect on the bond strength. The reason may be the difference in concentration or type of materials used.

Based on the results, it appears that air abrasion (roughening the composite surface by removing some resin matrix and exposing the filler surface) increases the shear bond strength for repair of ArtGlass indirect composite restorations. Moreover, silane application ranked second after air abrasion+ etching for improving bond strength taking into account that composite repair bond strength equal to the bond strength of composite to etched enamel (15-30 MPa) is clinically favorable.

Conclusion:

Based on the results, the highest and the lowest bond strengths were observed in groups 1 and 2, respectively. In other words, the highest bond strength in repair of ArtGlass composite restoration was achieved by air abrasion. Also, the results showed that silanization following air abrasion or HF acid etching also improves bond strength.

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Conflict of Interest: "None Declared"

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