Repair Shear Bond Strength Of Aged Resin Composite After Different Surface Treatments And Its Mode Of Failures: An In Vitro Study.

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Abstract:

Introduction: Composite resins are widely used in dentistry because of the great demand for aesthetic restoration**.** In addition, it is a less expensive alternative to indirect restorative treatment. With time, however, composite resin restoration can show wear, discoloration, fractures, or defects which may require their replacement.Total replacement of the restoration can cause significant loss of sound dental tissues and consequently weaken dental structure and cause pulpal injuries.The repair is a conservative process, so that there is no need for removing entire restoration and the minimum cavity preparation is required.The aim of the study is to evaluate influence of various surface treatment on shear bond strength of repaired composites and its mode of failures. **Methodology:**Seventy- twospecimens of composite were made by using cylindrical stainless steel mould. All the samples were thermocycled prior to surface treatment. All samples were divided into 1 control group (n=12) and five experimental groups (n=12) like 37% orthophosphoric acid, 9.6% hydrofluoric acid, diamond point, silane coupling agent and air abrasion with 50 µm Al_2O_3. After surface treatment fresh composite resin was bonded to treated surfaces prior to testing for shear bond strength using universal testing machine. Shear bond strength data were analyzed statistically using one way ANOVA test and Tukey HSD Test Post Treatment. After shear bond strength test, the samples were evaluated to determine the modes of failures. **Results:** Highest shear bond strength was observed in **air abrasion** but lowest shear bond strength was found in **control group** and cohesive failure were found predominatly in air abrasion.**Conclusion:**It was concluded that surface treatment with **air-abrasion** improves the repair bond strength and high bond strength groups exhibited cohesive failure.

Keywords: Composite, Repair, Mode of failures, Shear bond strength, Surface treatment

INTRODUCTION

Composite resins are widely used in dentistry because of the great demand for aesthetic restoration.[1] In addition, it is a less expensive alternative to indirect restorative treatment. With time, however, composite resin restoration can show wear, discoloration, fractures, or defects which may require their replacement.Total replacement of the restoration can cause significant loss of sound dental tissues and consequently weaken dental structure and cause pulpal injuries.[2]

So, repair is suggested instead of complete replacement of composite restoration because repair is conservative approach that prevents unnecessary loss of tooth structure and possible injury to dental pulp.[3]

However, in repair of composite restoration, it should be noted that changes that occur in composite resins over time due to aging including water sorption, chemical degradation and leaching of some compounds may decrease the reactivity of the remaining composite (old composite) and complicate the repair. To overcome this problem, some methods have been recommended to increase repair bond strength of composite.[4]

The bond strength between old and new composite interface depends on various surface treatments that include both mechanical and chemical methods. Roughening is the most common technique applied; the creation of mechanical interlocking between the materials is a significant factor contributing to improved bond strength between composites. Further, the probability of exposed, free carbon atoms on the surface is also increased, which could favor chemical bonding as well.[5] Several options for roughening the composite surfaces are available: rotary diamond burs, air abrasion with aluminium oxide, orthophosphoric acid, hydrofluoric acid etching and silane coupling agent. But, in various studies of all these techniques, contradictory results are still observed. Good results are still observed. Good results are directly related to the composition of the composites and the application protocol of the different techniques.[2]

Failure modes were classified as mixed, adhesive, cohesive. The failure is considered mixed if the adhesive interface and the composite material are included (prepolymerized substrate or repair material), adhesive failures, if the occurred at the resin/adhesive interface.[6] The location of the repair failure within the repaired material itself, rather than at the adhesive surface suggests a better bond.[7] Fractures within the composite resin (cohesive failure) seem to be more appropriate for bearing occlusal loads.[6]

Thus, the aim of the study was in vitro evaluation of influence of various surface treatments on shear bond strength of repaired composites and its mode of failures.

METHOD OF COLLECTION OF DATA:

Since the process wasn't intrusive**,** an in vitro preparation of composite blocks was done. So, ethical clearance was not needed.

Experimental design:

This study tested shear bond strength of repaired composite after different surface treatment (37% Orthophosporic acid, 9.6% Hydrofluoric acid, Silane coupling agent, Air abrasion, Green code diamond bur) and its mode of failures (Adhesive, Cohesive, Mixed).

Sample preparation:

Seventy-two specimens of composite were made by using cylindrical stainless steel mould of diameter 240 mm and height of 140 mm for the purpose of this in vitro study**(Fig 1)**. Acrylic resin was poured into stainless steel cylinder moulds that had been created for the specimens. On the cylindrical acrylic blocks, a hole measuring 80 millimeter in diameter and 40 millimeter in height was made. Holes were filled with nanohybrid composite (Ivoclar Vivadent, Tetric N-Ceram) of shade A3 to simulate existing restoration with incremental layering technique each of thickness two millimeter layer of composite was light cured for 40 sec by a L.E.D curing light (Woodpecker, China) for 40 seconds with wavelength of 420 nm- 480 nm and it was fully perpendicular to the mold.

Then specimens were subjected to the aging procedure by thermal cycling 1500 times between 5 ± 2 ºC and 55 ± 2 ºC, with a dwell and transfer time of 10 seconds interval time between the baths.

Fig 1: Samples

Surface Treatment

Afterward, specimens were randomly separated into 6 groups of 12 samples each, according to the surface treatment method**. (Fig. 2)**

Groups	Surface treatment employed	Brand name/ Manufacturer	Application methods
1	Control	–	–
2	37% Orthophosphoric acid	Ivoclar Vivadent Eco Etch,	Applied for 1 minute using microbrush on the surface was then

		Liechtenstein	washed for 45 seconds and dried with compressed air.
3	9.6% Hydrofluoric acid	Dentgen	Etched for 2 minutes using micr-obrush and then samples were washed and dried with compressed air.
4	Green code diamond point (125 µm to 150 µm)	Mani, Japan	Abraded the surface three times with coarse, tapered, rounded end diamond point using a high-speed handpiece and water spray
5	Silane coupling agent	ngelus, MERGO EUROPE Netherland	Silanized the surface for 10 seconds and dried for one minute with airspray.
6	Air abrasion with 50 µm Al_2O_3	Korox, BEGO, Germany	Abraded using micro-etcher at 3 bars pressure at a 5mm distance and 90ºC to the surface for 7 sec and then it was rinsed in water and air dried.

Table 1: Materials used and application protocols used in the study

Fig 2: Surface treatment

Repair Procedure

After different type of surface treatments, a new seventh- generation bonding agent (Beautibond, Shofu, Japan) was sprayed to the surface of aged composite, dried with compressed air, and light-cured for 5 seconds. Next, a piece of plastic hollow straw measuring 5 mm in diameter and 4 mm in height was placed in the centre of the flattened area of aged composite for each sample**(Fig. 3).** Then nanohybrid composite resin of A1 shades (Ivoclar Vivadent, Tetric N-Ceram), which was differed from original composite block was placed in order to differentiate between existing restoration and repaired restoration composite block with dimensions of 5 mm in diameter and 4 mm in height was constructed in 2 mm increments in thickness. An LED light curing device was used to light cure a mylar strip over the last increment for 20 seconds (Woodpecker L.E.D curing light). The straw was broken off and taken away. Then samples was submitted for shear bond test in a universal testing machine (Shimadzu, Japan) with a crosshead speed of 0.5 millimetres per minute until fracture**(Fig. 4).**

Fig 3: Repair procedure Fig 4: Testing procedure

Analysis of modes of failure:

After shear bond strength test, the samples were evaluated under a stereomicroscope (Labomed, Cz4 model, USA)at x40**(Fig. 5)**to check the modes of failures as

1. Adhesive: Failure at the interface
2. Cohesive: Fracture of base or repair composite
3. Mixed: Failure at the interface and the repair composite are included.

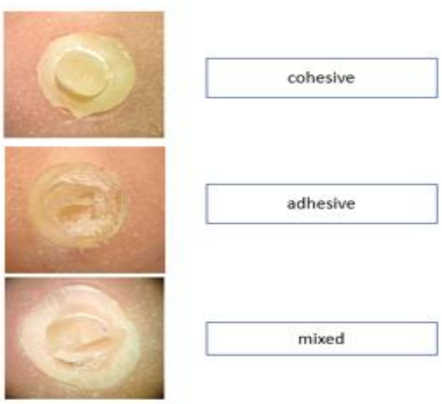


Fig 5: Mode of failures

STATISTICAL ANALYSIS

Analysis were performed using One-way ANOVA for multiple group comparisons and Tukey HSD Test Post Treatment for differences among mean. The data were analysed descriptively to obtain the mean and standard deviations for each group.

RESULTS

The mean and standard deviation values of Shear Bond Strength (N) of different groups represented in Table 1. The highest shear bond strength was found in group VI (Air abrasion) and the lowest in group I (Control). One-way ANOVA for multiple group comparisons and Tukey HSD Test Post Treatment for differences among mean. As shown in table 2, amongst all the groups showed significant difference **(p <0.001)** except comparison between Orthophosphoric acid **(Gp II)**and Hydrofluoric acid **(Gp III)** showed non-significant values **(p>0.001)**.

The percentage of fracture modes of the samples are illustrated in Table 3. The mode of failure was predominantly in (Gp VI) Air abrasion (**83.33%**) and Green bur(GpIV) **(75%)** groups. Most of the adhesive failure were recorded in control group (Gp I) followed by Orthophosphoric acid (GpII), Hydrofluoricacid(Gp III),SilaneCoupling agent (Gp V).

Tab 1 shows the mean shear bond strength comparison values of all the groups

Fig 6 shows the mean shear bond strength comparison values of all the groups

Fig 7 shows the mode of failure of different groups

Tab 2:The mean shear bond strength comparison values of all the groups

S.NO.	Control(Gp I)	Orthophosphoric(GpII)	Hydrofluoric(GpIII)	Green bur(GpIV)	SilaneCouplingagent (GpV)	Air abrasion(Gp VI)
1	320	550	607	790	650	847

2	280	580	625	780	710	810
3	370	610	604	690	730	870
4	350	560	590	730	680	790
5	310	650	670	720	750	830
6	340	620	630	750	670	850
7	290	565	605	710	705	821
8	300	585	590	695	715	845
9	315	590	595	725	690	810
10	325	580	585	727	655	835
11	295	605	615	752	665	822
12	300	640	610	745	680	844
MEAN	**316.25**	**594.58**	**610.50**	**734.50**	**691.67**	**831.17**
SD	**25.34**	**29.89**	**22.30**	**29.33**	**29.53**	**20.94**

Fig 6 The mean shear bond strength comparison values of all the groups

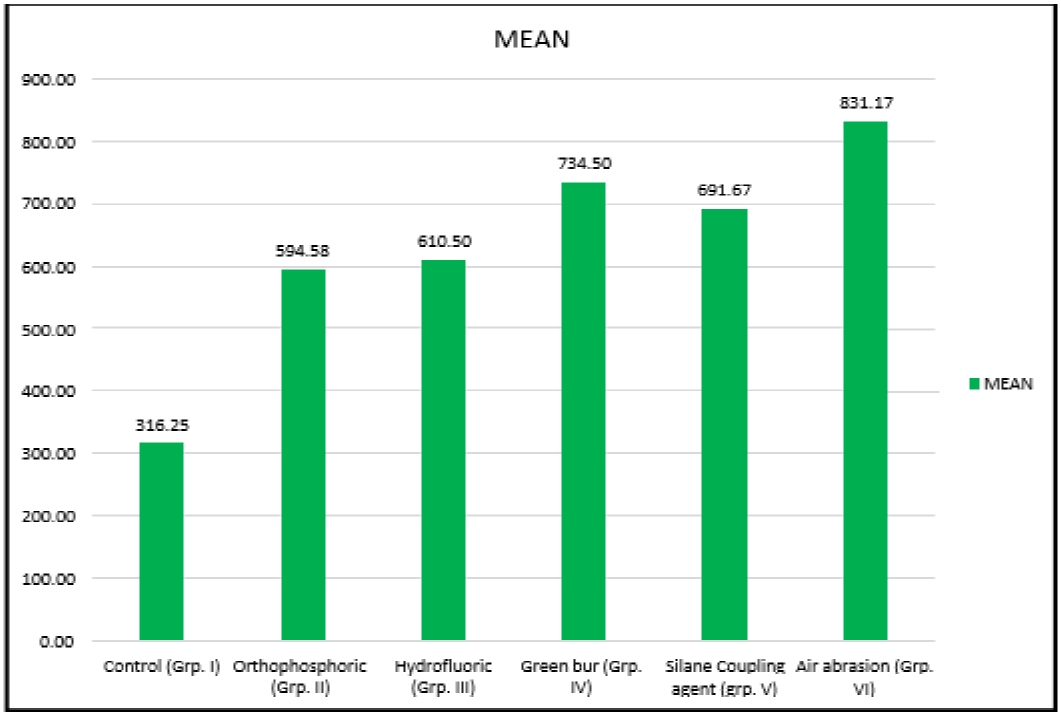
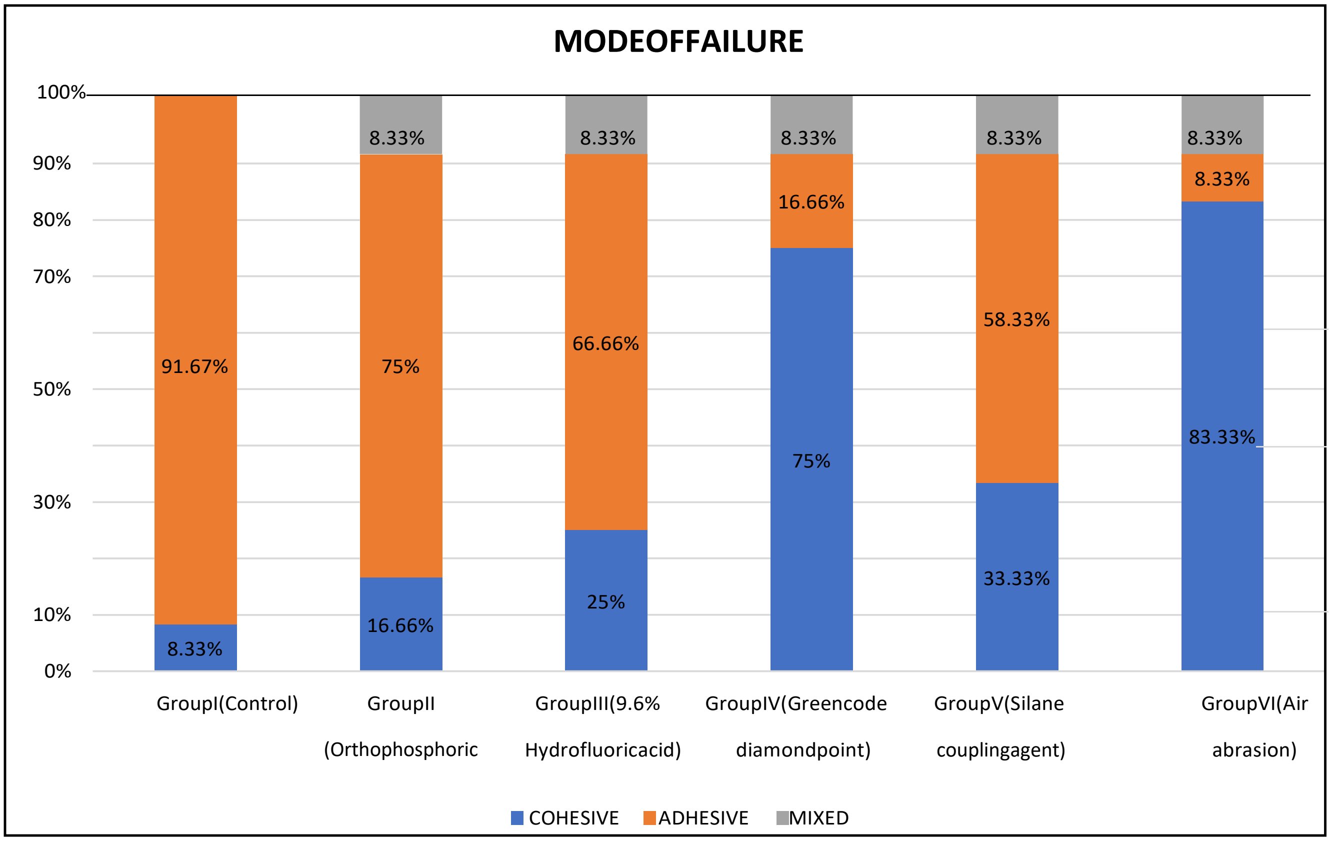


Fig 7 The mode of failure of different groups



DISCUSSION

Composite resin restorations are generally repaired years after the original placement. During the aging process, different phenomenon occur, including water sorption and hydrolytic, thermal, and chemical degradation, which can negatively affect the success of a composite resin repair.[8] An aging procedure is necessary to simulate clinical conditions when composite resin repairs are tested in vitro.[9]

Following aging, composites undergo structural changes due to water absorption, chemical degradation and leaching of some components as well as decreased activity of free radicals.[10,11,12] **Brosh et al.** stated that the bond between new and aged composite is achieved via three routes: Chemical bond with organic matrix, chemical bond with exposed filler particles and micromechanical bond via mechanical surface preparation.[13]Routine method for repair of composite restorations is via the use of diamond bur and removal of part of old composite followed by the use of phosphoric acid and adhesive.[14,15]

In fact, the outermost composite layer, which has been exposed to oral environment is removed. This creates irregularities on the surface and increases surface energy. This method is easy and effective for surface preparation and enhances the bond strength.[16,17]Following etching with phosphoric acid, surface morphology does not change significantly. In fact, this step aims to do a superficial cleaning following mechanical preparation.[18]

The ultimate goal of repairing composite restoration is to achieve adequate bond strength between old and new material.[5] In the present study, highest repair bond strength values were observed in groups that were surface treated. Roughening composite surface by either air-abrasion, bur, or etching can increase the bond to the repaired composite.

The control group without any surface treatment showed the lowest repair bond strength values.[19]. Adhesion between the aged and repair composite occurs by a mechanical surface treatment that produces surface roughness facilitating micromechanical interlocking to the repaired composite. Adhesion was also achieved by chemical bonding with the resin matrices and exposed filler particles.[5]

Shear bond strength tests are the most commonly used by the researchers to evaluate the adhesion properties of the adhesive systems. The shear test is a better representation of the forces clinically experienced by a restoration.[20]

Regarding the effect of surface treatment, the results of the current study revealed that the groups treated with air- abrasion with 50 µm aluminium oxide showed highest shear bond strength. This could be due to highly irregular surface produced by air abrasion, covered with pits and fissures caused by the impact of Al_2O_3 particles.[7] Papacchini et al. summarized that this surface with irregularities less than 10 µm in size and 5 µm in deptenhances the surface area, the surface energy of the composite substrate and increses its wetting properties, improving the bond strength between existing and repair composite materials.[21]

Air abrasion has improved the repair bond strength resulting in cohesive mode of failure. This could be due to increased surface roughness with large micro- retentive areas which enhances the wettability for adhesive system.[22]

The results of the present study coincide with the study done by **Cavalcanti et al. (2009)** who reported that surface treatment of direct composite with air- abrasion led to higher repair bond values compared with diamond burs.It was also reported air- abrasion produces micro- retention features, while a diamond bur generates micro- and macro- retentive features.[23] Higher bond strength is expected from air- abrasion, which yields micro- retention, because the adhesive resin infiltrates into the micro- irregularities of composite surface, resulting in better surface wetting.[24,25]

Nanohybrid composites have submicron silica fillers and zirconia particles.[15,19,22]

HF etching promotes micromechanical interlocking and silica- containing fillers are partially exposed due to etching, and the silane agents reacts with silica particles. Thus, it facilitates better shear bond strength in nanohybrid composites.[26]

All surface treatments produced improved shear bond strength to the repaired composite when compared with the control group and considered to be appropriate.

Considering failure modes, previous studies have reported that if a composite repair tends to fracture cohesively, it can be assumed that the selected protocol is appropriate to bear the occlusal loads.[23,27]

In the present study, on analyzing the failure modes according to the previous mentioned classification, most of the adhesive failure were recorded in control group which indicated the weak interfacial bond could be attributed to the absence of surface treatment during composite repair. Thus it is important to have treatment protocol in repairing composite restoration to obtain durable bond.[28]

In general, failure modes indicate that those groups with high bond strengths exhibited cohesive failure inside the composite. However, low bond strength groups tend to exhibit adhesive failure rather than cohesive failure.[29] More cohesive fractures were found in the stronger repair group and most cohesive failures were found in air- abrasion and diamond bur groups, which also had the highest mean repair strength.

This result agreed with Kashi et al**(30)** who found most of the adhesive failure occurred in control group. Our results also agreed with Fornazari et al **(31)** who found polished specimens exhibited over 80% adhesive failures.

This experimental study design provided no data on the long term stability of the adhesion achieved. Due to high shrinkage, composite repairs may start to crack after relatively short time in service. Further studies are required to address the effect of thermal cycling and long term storage in a moist environment on repair shear bond strengths to validate this shortcoming.

CONCLUSION

Within the limitation of this study, it was concluded that

1) Mechanical surface treatment of composite significantly improves the repair bond strength especially with air-abrasion compared with non-mechanical surface treatment.
2) Control group without any surface treatment showed the lowest repair bond strength values.
3) In air- abraded group cohesive failure was observed dominantly which could be assumed that the selected protocol was appropriate to bear the occlusal loads based on previous reported studies.

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