

The Effect of Various Composite Resin Types, Surface Treatments, and Repaired Materials on the Shear Bond Strength of Composite Resin Repair: An in Vitro Study

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Background and Objectives: Composite resin are widely used in the field of restorative dentistry, as the time passes, composite resin restoration are subjected to failure. This in vitro study conducted to evaluate the effect of two types of composite resin, surface treatment, and three types of repaired materials on shear bond strength.

Methods: Total of 120 undercut cylindrical cavities 8 mm in diameter in 2.5 mm in depth were cut at the center of self-cured acrylic resin blocks, the samples divided randomly according to the types of composite resin into 2 groups; microfilled and hybrid, the samples in each groups subdivided according to surface treatment; diamond bur and phosphoric acid. Then all the samples received bonding agent, these groups were subdivided into subgroups according to three composite repair materials. After that the samples were thermocycled manually 500 times, and then each bonded sample subjected to shear bond testing with a universal testing machine.

Results: The results showed that groups filled with hybrid composite had higher mean shear bond strength than groups filled with microfilled. Groups received surface roughness with diamond bur had higher mean shear bond strength than groups roughened by phosphoric acid. There was no significant difference in shear bond strength among groups repaired with different repaired materials. Groups received surface roughness with diamond bur and repaired with microfilled composite had higher mean shear bond strength among the other groups.

Conclusion: The highest repair bond strength was obtained by roughening the hybrid composite surface with diamond bur. There was no any significant difference in shear bond strength among groups repaired with different repaired materials, while combination of surface roughness with diamond bur and repaired with microfilled composite had higher mean shear bond strength.

Key words: Composite Resin, Repaired Materials, Surface Treatment, Shear bond Strength.

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Introduction

Composite resin materials have increasingly been used to replace missing tooth structure and to modify tooth color and contour.¹ The introduction of composite based resin technology to restorative dentistry was one of the most significant contributions in the last century.^{2,4} As time passes, composite resin restorations were subjected to failure. The most common causes of failure are; secondary caries, marginal staining, discoloration and cohesive fractures occurring to the incisal angle restoration.⁵ Fortunately, due to the properties of these materials, failure of a composite resin restor-

ation does not necessarily require removal of the entire restoration or even the preparation of undercuts for mechanical retention. Removal of a failed composite restoration completely would generally entail removal of previously etched enamel and then etching of more enamel in order to increasing the enamel bond. Complete removal will therefore inevitably lead to larger cavity with further loss of tooth substance and cause more traumas to the pulp. For this reasons, repair of an existing restoration would always be preferably to replacement providing that the repaired restoration is clinically satisfactory.^{6,7}

Materials and methods

A Tetric composite (Vivadent, Ets., Germany) which is a microfilled composite resin and XRV Herculite composite resin (Sybron/sds Kerr, USA) which is a hybrid composite resin in addition to Compoglass F (Vivadent, Germany) were used as restorative materials in this study. Prime and Bond NT (Dentsply/ Detrey, Germany), Diamond bur No. 1014 and phosphoric acid 37% (Dentsply/ Detrey, Germany) were used in this study.

Sample Distributions. The total of 120 undercut cylindrical cavities 8 mm in diameter and 2.5 mm in depth were cut at the centers of self-cured acrylic resin blocks which were poured in plastic tubes 2.5 cm in diameter and 3 cm in height. The samples divided randomly according to the composite resin types into two groups of sixty samples, group filled with hybrid composite resin and the other with microfilled composite resin. The samples in each group were subdivided randomly according to surface treatments into two groups of thirty samples in each. One group treated with diamond bur and the other group treated with 37% of phosphoric acid. Each of these groups were treated with bonding agent, in turn these groups were randomly subdivided into three subgroups of ten samples, each one to receive the restorative materials.

Groups treated with diamond bur: 30 samples from group filled with hybrid composite and 30 samples from group filled with microfilled composite received the roughening with diamond bur for 10 second; roughening for 10 second can increase the surface area and facilitate mechanical interlocking of adhesive, however, excessive roughness may hinder the even flow of the liquid adhesive and result in an air pocket being entrapped at the interface may in turn weaken the bond strength. One bur used to prepare six composite surfaces, after preparation of six surfaces, the cutting efficiency of the bur decreased for this reason one bur used to prepare six composite surfaces, then washed with water spray and dried with oil free air spray.⁸

Groups treated with phosphoric acid: 30 samples from group filled with hybrid composite and 30 samples from group filled with microfilled composite were acid etched with 37% phosphoric acid for 15 seconds, then the composite surface washed for 30 seconds with copious water to remove the phosphoric acid then air dried with oil free air for 15 seconds.

Adhesive application: A circular area 4mm in diameter was demarcated at the center of the composite base surface through the application of white adhesive tape with a circular hole 4mm in diameter so that the applied adhesive agent confined to a standardized area on the base, then all samples received Prime and Bond NT with sponge to the demarcated composite surface, air syringe was used for removing the solvent, and then light cured for 10 seconds according to the manufacturer instruction.

Repaired material placement: A cylindrical rubber mold with 4x4 mm dimension central hole was applied over the adhesive tape that was placed over the composite base, the mold was split vertically in one place through its entire thickness for facilitation of removing without putting undue stress on the repaired

material samples. Subsequently, the two type of composite and the compoglass were packed directly against the demarcated surface and adapted to avoid air entrapment in a two increments 2 mm thickness of each increment, the second increment covered with transparent celluloid strip and each increment light cured for 60 seconds according to the manufacturer instruction and to ensure that there was complete polymerization occurred. After that the rubber mold and adhesive tape were removed.

Thermocycling: The 120 samples were thermocycled manually for 500 times at temperatures ranging from 5 C° ± 2 C° to 55 C° ± 2 C°. Each cycle lasted 45 seconds with a dwell time of 15 seconds in each bath, and 15 seconds intervals between baths.⁹

Shear bond strength test: Each boned sample subjected to bond testing with a universal

testing machine with a knife edge rod 0.5 mm width at a cross head speed of 0.1mm/min that applied to composite base repaired material interface.

Statistical analysis. The experimental statistical design for the shear bond measurement was a two factor experiment in a complete randomized design. The data were analyzed using 2-factor analysis of variance (ANOVA) to indicate if there were any statistical differences in shear bond strength at 0.01 significant levels. Duncan multiple range tests and least significant difference test were used to compare between the significantly different groups.

Results

The descriptive statistic for each experimental groups are shown in Table (1).

Table 1: The Mean and Standard Deviation of SBSs for repaired tested groups.

| Groups | N | Mean (Mpa) | ± SD | Lower value | Upper value |
|--------|----|------------|-------|-------------|-------------|
| RM B T | 10 | 15.28 | 1.902 | 12.81 | 17.38 |
| RM B H | 10 | 11.52 | 0.817 | 10.98 | 12.81 |
| RM B C | 10 | 14.84 | 1.019 | 12.44 | 18.30 |
| RM P T | 10 | 10.97 | 1.146 | 9.15 | 14.14 |
| RM P H | 10 | 12.71 | 2.676 | 10.52 | 16.47 |
| RM P C | 10 | 9.78 | 0.891 | 8.68 | 10.98 |
| RH B T | 10 | 16.56 | 0.384 | 16.01 | 16.93 |
| RH B H | 10 | 13.81 | 1.470 | 11.98 | 16.47 |
| RH B C | 10 | 15.00 | 0.595 | 14.64 | 16.01 |
| RH P T | 10 | 13.63 | 1.951 | 10.98 | 16.47 |
| RH P H | 10 | 15.18 | 1.790 | 11.89 | 17.30 |
| RH P C | 10 | 13.08 | 1.356 | 10.98 | 14.64 |

(Mpa = Mega Pascal., N= Number of Samples.,RM = Repaired Microfilled Composite. RH = Repaired Hybrid Composite. B = groups treated with diamond bur. P = groups treated with phosphoric acid. T = groups repaired with tetric composite resin. H = groups repaired with Herculite composite resin. C = groups repaired with compoglass)

Analysis of variance (ANOVA) and Duncan's multiple range test were used for levels of composite resin types, surface treatment, and repaired materials and their interaction, Table (2) illustrated ANOVA at 0.01 significant levels finding. Analysis of Variance showed that there was a significant difference in shear bond strength between

groups filled with microfilled composite and groups filled with hybrid composite. Duncan's multiple range test for comparing the two materials, showed that groups filled with hybrid composite had higher mean shear bond strength than groups filled with microfilled. Illustrated in Table (3).

Table 2: Analysis of variance for levels of composite resin types, surface treatment, repaired materials, and their interaction.

| Source of Variance | DF | Sum of Square | Mean of Square | Calculated F value | Tabulated F value | Significance |
|--|----|---------------|----------------|--------------------|-------------------|--------------|
| Restorative Materials | 1 | 61.37 | 61.37 | 16.20 | 7.31 | 0.01** |
| Surface Treatment | 1 | 56.34 | 56.34 | 14.78 | 7.31 | 0.01** |
| Repaired Materials | 2 | 10.27 | 5.135 | 1.34 | 5.18 | N.S |
| Restorative Materials X Surface Treatment | 1 | 9.06 | 9.06 | 2.37 | 7.31 | N.S |
| Restorative Materials X Repaired Materials | 2 | 1.05 | 0.52 | 0.13 | 5.18 | N.S |
| Surface Treatment X Repaired Materials | 2 | 77.71 | 38.85 | 10.19 | 5.18 | 0.01** |
| Restorative Materials X Surface Treatment X Repaired Materials | 2 | 5.43 | 2.71 | 0.71 | 5.18 | N.S |
| Error | 48 | 183.06 | 3.81 | | | |
| Total | 59 | 404.65 | | | | |

(** = highly significant. N.S = not significant.)

Table 3: Duncan's multiple ranges test for the effect of composite type as a substrate on shear bond strength.

| Composite type | N | Mean (Mpa) | ± SD | Duncan Grouping |
|----------------|----|------------|-------|-----------------|
| Microfilled | 30 | 12.51 | 2.342 | A |
| Hybrid | 30 | 14.54 | 1.216 | B |

Note: means with different letters are statistically different.

On the other hand, Analysis of Variance showed that there was a significant difference in shear bond strength between groups treated with diamond bur and groups treated with phosphoric acid. Duncan’s multiple range test, showed that groups received surface roughness with diamond bur had higher mean shear bond strength than groups received surface roughness with phosphoric acid. Illustrated in Table (4). While Analysis of Variance showed that there was no significant difference in shear bond strength among groups repaired with different repaired materials.

Analysis of Variance revealed that the interaction between composite types and surface treatment has no significant effect on shear bond strength and the interaction

between composite types and repaired materials has no significant effect on shear bond strength, but the interaction between the surface treatment and repaired materials has a significant effect on shear bond strength. Duncan’s multiple range test was performed topographically determine the best interaction, showed that groups received surface roughness with diamond bur and repaired with microfilled composite had higher mean shear bond strength among the other groups. Showed in Table (5).

Analysis of variance revealed that the interaction among composite resin types, surface treatment and repaired materials has no significant effect on shear bond strength at 0.01 significant level.

Table 4: Duncan’s multiple ranges test for the effect of surface roughness on shear bond strength.

| Surface treatment | N | Mean (Mpa) | ± SD | Duncan Grouping |
|-------------------|----|------------|-------|-----------------|
| Diamond Bur | 30 | 14.50 | 0.972 | A |
| Phosphoric acid | 30 | 12.55 | 1.854 | B |

Note: means with different letters are statistically different.

Table 5: Duncan’s multiple range test for interaction between surface roughness and repaired materials.

| Groups | N | Mean (Mpa) | ± SD | Duncan Grouping |
|-------------------------|----|------------|-------|-----------------|
| Bur + Tetric | 10 | 15.92 | 0.354 | A |
| Bur + Herculite | 10 | 12.66 | 0.842 | B |
| Bur + Compoglass | 10 | 14.92 | 0.291 | C |
| Phosphoric + Tetric | 10 | 12.3 | 0.862 | D |
| Phosphoric + Herculite | 10 | 13.94 | 1.245 | E |
| Phosphoric + Compoglass | 10 | 11.43 | 1.798 | F |

Note: means with different letters are statistically different.

Discussion

The shear bond testing is one convenient mode of testing adhesive interface that is well established in biomaterials research, in addition to that the shear bond strength test ignores the nature of stresses generated within adherence zone. Various factors affecting the repair strength, such as time of repair, surface roughness, intermediary materials, and repair materials used.^{10,11}

The results in this study showed there was a significant difference in shear bond strength between groups filled with hybrid composite and groups filled with microfilled composite and also the result showed that the hybrid groups had higher mean shear bond strength than microfilled, this result may be due to the component of composite resin and surface properties of each type of composite that were used in this study; the microfilled composite contain small particle size filler result in smooth, polished surface while hybrid composite contain large particle size inorganic filler result in rough surface, the roughness is the important feature for good bond strength between old and new composite, this may explain why hybrid composite had higher shear bond strength than microfilled composite.¹²⁻¹³

The results in this study, showed that roughening of an old composite surface was essential step when repairing the composite restoration with a new composite. The groups in which the composite surface received roughness with diamond bur had higher shear bond strength than groups received roughness with phosphoric acid; roughening with diamond bur remove outer surface layer and expose the filler particles creating micro retentive features as well as micro retention, the increasing the micro retentive features increase the surface area of composite surface and increase penetration and wettability of the resin which substantially improve bond strength.⁷⁻¹⁴⁻¹⁵ The above discussion explains

also why combination of hybrid composite with received surface roughness with diamond bur and repaired with microfilled composite had higher mean shear bond strength, simply because the hybrid composite has rough surface then the roughness with diamond bur exposed large particles size filler; this increase the gaps and porous between fillers and improve penetration of resin in microfilled composite and bonding agent subsequently increase the bond strength.

Conclusion

The highest repair bond strength was obtained by roughening the hybrid composite surface with diamond bur. There was no any significant difference in shear bond strength among groups repaired with different repaired materials, while combination of surface roughness with diamond bur and repaired with microfilled composite had higher mean shear bond strength.

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