

The shear bond strength of an immediate and delay repaired light-cure composite restoration (In vitro study)

Angham G. AL-Hashimi B.D.S, M. Sc.⁽¹⁾

Abdulkarim J Al-Azzawi B.D.S, M. Sc.⁽²⁾

Haitham J Al-Azzawi B.D.S, M. Sc. USA⁽²⁾

ABSTRACT

Background: Defects in composite resin restoration whether discovered at the time of placement or associated with old composite resin restoration could be repaired without replacing the entire restoration. This in vitro study was conducted to determine and compare the shear bond strength of an immediate and delay repaired light cured composite restoration.

Materials and methods: Eighty acrylic blocks (25x25x15 mm) were constructed from cold cure acrylic resin; each one contained an acrylic hole (6mm diameter and 3mm depth) that filled with Helioprogross composite resin. The surface layer of the composite resin samples was light cured through plastic strip, abraded by finishing discs and rinsed with deionized distilled water for 15 sec. The eighty specimens were divided randomly into two groups according to the storage time in deionized distilled water before the repair:

Group I: Stored for 15 min. (Immediate repair group)

Group II: Stored for 1week. (Delay repair group)

Both groups were subdivided into 4 subgroups according to the surface treatment they received:

Subgroup 1: No surface treatment (control)

Subgroup 2: 37% phosphoric acid etchant (15 sec.)

Subgroup 3: Heliobond (light activated for 20 sec.)

Subgroup 4: 37% phosphoric acid and Heliobond.

Repair was done by using a standardized translucent plastic straw (3mm diameter and 6mm length) and was filled Helioprogross composite resin and light cured for 40 sec. in four directions. All the specimens were stored in deionized distilled water for 24 hr. testing was done by the Zwick testing machine by applying shearing force with specially designed chisel-shape rod. Data obtained were statistically analyzed using analysis of variance test and t-test.

Results: The results showed very highly significant difference between the similar subgroups in group I vs. group II and there was non-significant difference between subgroup 1 vs. 2 and between subgroup 3 vs. 4.

Conclusion: Delaying the repair procedure for 1 w resulted markedly reduced the bond strength, the surface treatment with 37% phosphoric acid slightly reduced the bond strength in the immediate repair while slightly increased it in the delay repair, Furthermore, the surface treatment with Heliobond fifth generation bonding agent markedly increased the bond strength in both repairs.

Keywords: Repair, composite, shear bond. (J Bagh Coll Dentistry 2011; 23(sp. issue):5-9).

INTRODUCTION

Patient interest in dental aesthetics has resulted in the development of new restorative materials and techniques. Composite materials and adhesive techniques have become the foundation of modern restorative dentistry⁽¹⁾.

Newly placed composite restorations are sometimes considered unacceptable or unsatisfactory; the main reasons for this included in adequate contour, over finishing, color mismatch, presence of voids or fractures. Furthermore the old composite restorations may also be considered an unacceptable due to failed bond, color changes and loss of surface through chemical and mechanical deterioration^(2,3).

In both instances the usual recourse is to either repair or replace the restoration. Repair carries the advantages of being less expensive with less potential pulpal trauma^(4,5).

One measure of reparability is the development of excellent bond at the interface between the initial and the repaired layer.

In addition to the surface quality; the surface treatment would affect the bond strength, the repaired surfaces of the restoration, and usually referred as the interfacial bond strength⁽⁵⁾.

The Strength of the repaired resins ranged from one fifth to one half of the Strength of the un repaired composite resin, such a repair may be clinically satisfactory, although mechanical retention may be needed in areas where there is exposure to biting forces⁽⁶⁾.

Techniques for mechanical preparation of the defective composite resin surfaces to enhance retention of the new composite resin to old one have been widely evaluated and reported, also the opportunity for chemical bonding has been studied⁽³⁾.

The shear strength of bond between mature and new composite filling materials was studied. The important of factors such as the water content of mature composite, the brand of

(1) Assistant lecturer in conservative department-Collage of dentistry-Baghdad University

(2)Professor in conservative department-Collage of dentistry-Baghdad University

composite used and the effect of time on the bond strength were determined⁽⁷⁾.

Application of acid either increase or decrease bond strength^(8,9). While the application of bonding agent increased the bond strength^(5,10).

The question of the possible repair of composite filling has already received some attention. The researchers decided to continue the research on this topic because of the wider range of materials now available, changes in formulation and structure of composite, modification in specimen preparation and testing procedure used in the investigation.

Such factors make quantitative comparison between the various in investigation difficult. Nevertheless, it is possible to relate some observations to each other⁽¹¹⁾.

This in vitro study was conducted to determined and compare the shear bond strength of an immediate and delay repaired light-cure composite restoration and to assess the effect of acid and/or bonding agent on this strength.

MATERIALS AND METHODS

Eighty acrylic blocks (25x25x10mm) were constructed from cold-cure acrylic resin, containing a cylindrical hole (6mm diameter and 3 mm depth) in the center of one of its square faces to act as a mold for the composite resin sample.

Each block was constructed using a dry clean glass slab, a sheet of copper (fabricated in a hallow box form of 25x25x10 mm) and a cylindrical piece of sheet wax (that have been cut off through 6mm diameter copper ring placed in the center of the box).

The cold-cure acrylic resin was applied and after complete polymerization, the acrylic block was placed in boiling water for 1/2 h. to get rid of the wax and the free monomer⁽¹²⁾.

The microfilled light-cure composite resin (Helioprogress Vivadent, Germany) had fill the hole of each block according to its manufacturer instructions and in two layers:

- (i). First layer of (1.5 mm depth) composite resin was applied with plastic instrument, cured with visible light-cure unit for 40 sec.
- (ii). Second layer (the surface layer) of composite resin slightly over-filled the rest of the hole and covered with a glass slide after placing of the plastic strip followed by light activation for 40sec⁽¹²⁾.

The surface layer was abraded by finishing discs used with a low speed hand-piece mounted on surveyor (1 coarse sofex disc for each sample)⁽¹³⁻¹⁵⁾.

The test surface of each specimen was rinsed with air-DDW spray for 15 sec. to clean the abraded surface^(10,16).

The eighty specimens were divided according to their storage time in to two groups: (Figure 1)
Group I (Immediate repair group): Forty specimens stored in DDW placed in a constant temperature oven at 37 C^{o(10,11)} for 15min⁽¹⁷⁾.

Group II (delay repair group): Forty Specimens stored in DDW placed in a constant temperature oven at 37 C^{o(10,11)} for 1 W⁽¹⁷⁾.

Each group had been subdivided into 4 subgroups according to the type of surface treatment they received, each one contained 10 specimens:

Subgroup I control group: In which the repair procedure of the composite resin sample carried directly on the dried surface of the sample.

Repair procedure

It involves the placement of (3mm diameter and 6mm length) cylindrical piece of standardized translucent plastic straw that have been cut using surgical blade No. 15 and filled with the microfilled composite by a plugger. The vertical position of the composite cylinder was checked by using a rectangular ruler. The excess material was removed by probe, and the bonded piece of composite cylinder was cured for 40 sec. in four directions. Filled with the microfilled composite by a plugger.⁽¹⁸⁾

Subgroup 2 (acid group): The surface layer was treated with 37% phosphoric acid gel for 5 sec., washed with air-DDW spray for 30 sec. and dried for 10 sec. Then; the repair procedure was done⁽⁵⁾.

Subgroup 3 (bonding agent group): The surface layer of the specimen was coated with thin layer of unfilled acrylic resin (Heliobond. Vivadent. Germany) by a disposable brush, light cured for 20 sec., followed by the repair procedure.

Subgroup 4 (acid - bonding agent group): The surface layer treated with acid, after that the bonding agent was applied then the repair procedure was done.

All the specimens were stored in DDW, placed in a constant temperature oven ac 37 C^o for 1day^(19,20). Shear bond strength was evaluated with the Zwick testing machine using a specially designed stainless steel chisel-shaped rod (Fig.2) with a cross-head speed of 5mm/min. The load cell was set at 100 Kg. The test specimens were placed in the lower member (Jaw) of the testing machine in such a way that the long axis of the chisel-shaped rod was parallel to the surface layer of the composite resin sample and perpendicular to the long axis of the composite resin cylinder.

The specimens were stressed to failure after securing them tightly in place. The mode of failure was examined by a magnifying lens^(14,21).

Examination of fractured repair surfaces indicated adhesive failure with all treatment groups.

The force was recorded in Newton's, which was then divided by the surface area (7.065 mm²) to obtain the shear bond strength values calculated in Mpa.

The data were analyzed using one-way Analysis of variance test (ANOVA) was performed to test and statistical significant difference between and within groups, followed by student -t-test was used when F ratio was significant to investigate where the significant differences occur.

RESULTS

The mean values, standard deviations. Maximum and minimum values are presented in Table 1.

It is clearly obvious that delaying the repair procedure resulted in marked reduction in shear bond strength values, while immediate repair resulted in higher shear bond strength values.

Group I (immediate repair - subgroup 3 (bonding agent group) showed the highest mean of shear bond strength values.

Delay Repair The statistical analysis of the data by one-way- ANOVA test for group II showed that a statistical very repair) subgroup 1 (control) showed the lowest mean of shear bond strength values.

In addition, the surface treatment with 37% phosphoric acid gel for 15 sec. showed no obvious change in the means of the shear bond strength values, while the application of Heliobond resulted in marked increase in the mean of shear bond strength values in both repairs.

Immediate Repair. The statistical analysis of the data by one-way ANOVA test for group I showed a statistical very highly significant difference at p<0.001.

The results of the test showed that there were statistical very highly significant differences between:

- Subgroup 1 vs. subgroup 3
- Subgroup 2 vs. subgroup 3
- Subgroup 1 vs. subgroup 4
- Subgroup 2 vs. subgroup 4

In addition, there were no statistical significant differences between:

- Subgroup 1 vs. subgroup 2
 - Subgroup 3 vs. subgroup 4
- Highly significant difference at p<0.001.

The results of t-test showed that there were statistical very highly significant differences between:

- Subgroup 1 vs. subgroup 2.
- Subgroup 2 vs. subgroup 3
- Subgroup 1 vs. subgroup 4
- Subgroup 2 vs. subgroup 4

In addition, there was no statistical significant difference between:

- Subgroup 1 vs. subgroup 2
- Subgroup 3 vs. subgroup 4

Comparison between similar subgroups. The statistical analysis of the data by one-way ANOVA test for group I and II showed a statistically very highly significant difference at p<0.001

The results of the t-test showed that there were statistical very highly significant differences between all the similar subgroups in both immediate and delay repair groups.

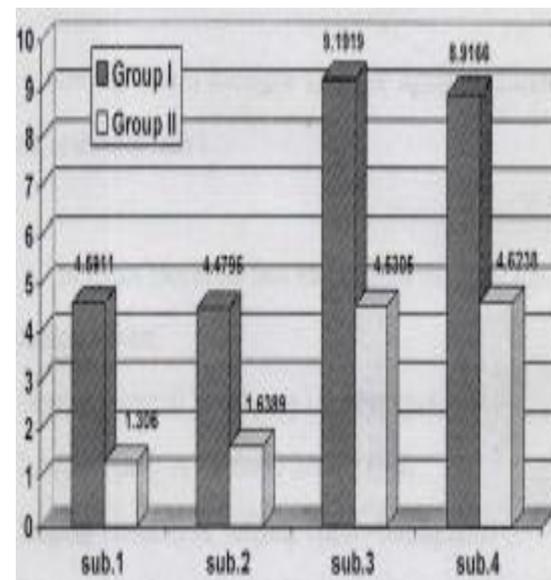


Figure 1: The means of shear bond strength, values in Mpa for all the groups and subgroups.

Table 1: Descriptive statistics of the shear bond strength value in Mpa.

*	Mean		Standard deviation		Minimum value		Maximum value	
	GI	GII	GI	GII	GI	GII	GI	GII
1	4.5	1.3	1.9	0.5	2.1	0.3	7.7	2.0
2	4.4	1.6	1.6	0.6	1.7	0.6	7.5	2.6
3	9.1	4.5	2.6	1.1	6.6	3.0	15.9	7.3
4	8.9	4.6	2.7	1.7	4.3	1.6	13.4	7.5

*Subgroup No.

DISCUSSIONS

Immediate Repair. The surface treatment with 37% phosphoric acid gel for 15 sec. resulted in a non significant reduction in the mean of shear bond strength values. These finding were resulted from the combined effect of the acid and the finishing disc. The acid resulted in exfoliation of some of the surface fillers that have been disturbed and their silane interface break-down during the friction of the finishing disc⁽¹⁶⁾, the filler particles size in the Helioprogress composite resin range from 0.01 to 0.1 μm , their exfoliation resulted- in reduction in the depth of the 2.02 μm surface roughness that has been resulted from the finishing disc^(21,22), and created surface voids instead of tag forming surface irregularities. The surface voids form no tags and decrease the wetting ability of the bonding of the newly placed composite resin in the repair procedure^(23,24). These finding agree with Swift et al^(8,9) and Brosh et al⁽¹⁰⁾, while disagree with Lewis et al⁽⁵⁾. such a difference in the result related to the difference in the technique of repair in Lewis et al⁽⁵⁾ methodology that ignore the rinsing of the testing surface after being abraded by finishing disc.

The surface treatment with Heliobond resulted in statistical very highly significant increase in the mean shear bond strength values in Mpa.

These observations coincide with the fact that bond strength is a function of wettability⁽⁷⁾. The unfilled acrylic resin enhanced the wettability of the filled acrylic resin by infiltration of the resin in to the microscopic surface⁽²³⁾. Thus improved the chemical bond formation (to the matrix and the exposed filler particles) and improved the micro mechanical bonding (that resulted from the hybrid layer formation with the rough composite surface⁽¹⁰⁾) therefore resulted in higher bond strength values. These observations agree with Pounder et al⁽³⁾, Puckett et al⁽²⁵⁾, Brosh et al⁽¹⁰⁾ and Shahdad et al⁽²⁶⁾.

Delay Repair. The surface treatment with 37% phosphoric acid gel for 15 sec resulted in a non significant increase in the mean of shear bond strength values in Mpa

These results demonstrate the combined effect of three factors (water storage, acid and finishing disc) the water storage resulted in leachable ions, and decomposition of the water unstable silane coupling agent resulting in a reduction in the composite resistance to acid⁽²¹⁾, the 37% phosphoric acid gel acts on such composite in a similar way of that in the immediate repair, in addition to cleaning and

freeing of the uncleanable firmly adhered smear layer in the microcracks in the matrix⁽¹⁶⁾ that has been previously resulted from the finishing disc. Thus the acid increased the surface irregularities and producing microretentive tag forming surface that aid in retention in addition to the surface voids that restrict the wetting⁽²⁴⁾. The overall results in this study showed non significant increase in the mean of shear bond strength values.

These results agree with results obtained by Boyer et al⁽⁶⁾ and Swift et al^(8,9) Yap et al⁽²⁷⁾ while disagree with where the results obtained showed a reduction in mean shear bond strength values when the test surface treated with acid prior of the repair of air abraded composite resin surface. Such a difference in the results related to the differences between the effect of air abrasion (which produce irregular surface not accompanied with microcracks and polishing disc on the composite resin surface.

The surface treatment with Heliobond resulted in a statistical very higher significant increase in the mean of shear bond strength values. These results attributed to the fact that coating an old composite with an unfilled resin advances the surface wetting⁽¹⁰⁾. Thus improved the chemical bond formation to the matrix and exposed filler particles and improved the micromechanical bonding (that resulted, from the hybrid-layer and from the resin tags that have been formed by the penetration of the bonding agent to the microcracks in the matrix^(10,16)). Therefore, resulted in a higher shear bond strength values. These results agree with the results that obtained by Boyer et al⁽⁶⁾ and Turner et al⁽¹⁵⁾.

Comparison between Similar Subgroups: The results of this study showed statistical very highly significant differences between control, acid, bonding agent and acid+ bonding agent subgroups (immediate and delay repair groups). This sharp decrease in the means of shear bond strength values from immediate to delay repair attributed to the combined effect of two factors (the water storage and the degree of polymerization⁽⁶⁾). The water storage resulted in a wet composite that has a more hydrophilic surface than the dry newly placed composite, therefore, reducing the wetting ability and bond strength.

Furthermore, the amount of the remaining unreacted double bond that permits chemical bond formation between the new composite and the old composite had been reduced, further polymerization took place by time and water

storage^(11,28). These results agree with Chestnutt et al⁽⁷⁾, Flares et al⁽¹⁸⁾ and Shaffer et al⁽¹²⁾.

REFERENCES

- Dietschi D, Dietch JM. Current development in composite materials and techniques. *The Intern Aesthetic Chronicle* 1996; 8(7): 603-13
- Cauchie D. Repairing porcelain and ceramic materials. *Curr Opin Cosmet Dent* 1995: 89.
- Pounder B, Gergory WA, Power Jm. Bond strength of composite resins. *Oper Dent* 1987; 12: 137-41
- Leinfelder KF. New developments in resin restorative systems. *JADA* 1997;128: May: 573-81
- Lewis G, Johnson W, Martin W, Caneder A, Claburn C, Collier M. Shear bond strength of immediately repaired light-cured composite resin restoration. *Oper Dent* 1998; 23: 121-7.
- Boyer DB, Chan KC, Torney DL. The strength of multilayer and repaired composite resin. *J Prosthet Dent* 1978; 39(1): 63-7.
- Causton BE. Repair of abraded composite fillings. *Brit Dent J* 1975; 7:286-8.
- Swift EJ, Le Vally BD, Boyer DB. Evaluation of new methods for composite repair. *Dent Mater* 1992; 8(6):362-5.
- Swift EJ, Brodeur C, Cvitko E, Pires JA. Treatment of composite surface for indirect bonding. *Dent Mater* 1992; 8(3): 193-6.
- Brosh T, Pilo R, Btchacho N, Blutstein R. Effect of combinations of surface treatments and bonding agents on the bond strength of repaired composites. *J Prosthet Dent* 1997; 77(2): 122-6.
- Van ker chhoven H, Lambrechts P, Vanbeyen M, Davidson CL, Van herlen G. Unreacted methacrylate groups on the surface of composite resins. *J Dent Res* 1982;51(6): 791-5.
- Shaffer RA, char DG, Hennesch CB. Reparability of three resin-modified glass-ionomer restorative materials. *Oper Dent* 1998; 23(4): 168-72.
- Hoelscher DC, Lneme AM, Pink FE, Hughes PJ. The effect of three finishing systems on four esthetic restorative materials. *Oper Dent* 1998; 23:36-42.
- Robbins JW, Cooley RL, Duke ES, Berrong JM. Repair bond strength of glass-ionomer restoratives. *Oper Dent* 1989; (3) 129-32.
- Turner CW, Meiers JC. Repair of an aged-contaminated indirect composite resin with a direct visible-light-cured composite resin. *Oper Dent* 1993; 18 (5):187-94.
- Noort RV, Davis LG. The surface finish of composite resin restorative material. *Brit Dent J* 1984; Nov: 360-4.
- Brlotti RL. Total etch-the (rational dental bonding protocol. *J Esthet_Dent* 1991:(3) 1-6.
- Flare S, Chariton D, Evans DB. Reparability of polyacid-modified composite resin. *Oper Dent* 1995; 20(5):191-6.
- Al –Mormani AS. A Study on the effect of time on bond strength using two adhesive bonding systems. *Dental News* 1999; (1)6: 36-9.
- Berg T, Barghi N, Chung K. Effect of water storage on the Silanization in porcelain repair strength. *J Oral Rehab* 1999; Jun: 26: 459-63. (abstract)
- Craig GR, Marcus L. Restorative dental materials. 10th ed. Mosby. 1997;ch. 10:244-248
- Sturdivent CM, Roberson TM, Hegmann SO, Sturdivent JR. The art and science of operative dentistry. 3rd ed. Mosby. 1995;ch.6: 207-283
- Bauman L, McCoy RH. Advanced restorative dentistry. 2nd ed. W.B. Saunders Company, 1984; ch9: 142-54.
- Latta Ma, Barkmier WW. Bond strength of resin cement to cured cement to cured composite inlay material. *J Prosthet Dent*1994;72 (2): 189-93.
- PucKett AD, Holder, O'ltara JW. Strength of position composite repair using different composite /bonding agent combinations. *Oper Dent* 1991; 16(4): 136-40.
- Shahdad SA, Kennedy TG. Bond strength of repaired anterior composite resin: an in vitro Study. *J Dent* 1998; 26(8): 685-94.
- Yap AUU, Quek CE, Kau CH. Repair of new generation tooth-colored restorations: methods of surface conditioning to achieve bonding. *Oper Dent* 1998; 23(4): 173-8.
- Peatzfeld A. Quantity of remaining double bonds diacetyl containing resins. *J Dent Res* 1994; 73(2):511-5.