Comparison of Shear Bond Strength of Composite to Composite Bond in Increment Technique (An in vitro study)

Sattar J. Abdul-Zahra Al Hmedat* and Zuha Ayad Jaber
Department of Conservative Dentistry, College of Dentistry, University of Kufa, Najaf, Iraq

Introduction

In recent years, the use of direct composite resin for cosmetic restoring posterior and anterior teeth has increased dramatically. The apply of direct resin composite to materials of composite has become a dynamic part of cosmetic Operative Dentistry. Currently, the options for placing direct tooth coloured restorations are either by the incremental or bulk fill approach. The rationale for incremental layering are:

1. Incremental placement techniques are widely recognized as a major factor in the reduction of polymerization shrinkage stresses.
2. The color matching of the composite restoration with the natural tooth color requirements a different shade of composite that was added in Incremental placement techniques to obtain an optimum color match and anatomy of the natural tooth.
3. The esthetic appearance associated with preparations the cavity conservatively and the constantly improved properties has made the esthetic materials the perfect choice for all classes of restorations [1].
4. The most universal hybrid composites can only be cured to a depth of 2 mm, and hence successive layers are necessary to fill the cavity.

Furthermore, successive layers reduce the cavity configuration factor (C-factor) for lowering pulpal deflection and mitigating bond failure following polymerization.

Abstract

Objective: Bonding composite to composite restorations in increment technique. The objective of this in vitro study was to determine the best procedure and bond to enhancing the bond between two incremente composite, by measuring shear bond strength between two new incremente composites, surfaces were treated with a bonding agent (Bond Universal [3M ESPE]), mechanical retention by roughening surface with diamond bur and air isolation of cured composite.

Methods: Four groups and each group composed of 20 composite blocks. The block prepared at dimension: (3, 3, 2 mm) made from 3M ESPE Nano Hybrid Z 250XT. First group: Oxygen -polymerization inhibited specimens (20 block). Second group: Inhibition formed of Oxygen - polymerization inhibited specimens (20 block) by using celluloid strip. Third group: all in one adhesive system (one bottle/self etching 3M ESPE single bond universal adhesion material which contained silane) specimens (20 block) Four group: grinding specimens (20 block) of composite by diamond bur. Using The VALO Cordless curing light has multi-wavelength (395 - 480nm) Light Emitting Diode (LED).

Results: Experimental shear bond strengths Direct group 32.14 ± 1.148 (Mpa), Bond group 30.75 ± 1.854 (Mpa), celluloid Strip group 13.73 ± 1.301 (Mpa) and Grinding group 19.67 ± 1.919 (Mpa). The higher shear bond strength in direct and bond groups and non significant with lowest mean result of strip and grinding groups. was used to analyze data. One way ANOVA (F-test) was used to detect the significant differences between groups. L.S.D was used to compare mean differences between each two groups (multiple comparison). P≤0. 01 was considered to be significant at 1%.

Conclusions: Depending on the mechanical property being tested, group treatments with all in one adhesive system (one bottle/self etching 3M ESPE single bond universal adhesion material and direct group produced different results, produced more consistent results than grinding and celluloid groups.
shrinkage. The disadvantage of incremental layering is the onerous process with a greater probability of introducing porosity between the layers. Cosmetic dental practice requires a restorative technique that can be quickly and easily placed with a reliable adhesion to composite structures [2].

This thesis contains a study into different aspects related to the union of two new increments composite, with the purpose of identifying factors affecting the composite-to-composite adhesion, as well as selecting improved materials and procedures for enhancing coupling potential. In this thesis compare the effect of oxygen inhibiter layer and the absence of this layer of the union of two increments of composite. Oxygen reacts with carbon-based polymerizing free radicals in a diffusion-controlled manner to form peroxy radicals. As they are much less reactive towards double bonds, the efficiency of initiation is reduced, leading to significant retardation (or even inhibition) of the polymerization. These undesirable reactions with oxygen occur prevalently at the air interface where the concentration of $O_2$ is around $10^{-2}$-$10^{-3}$ M, in contrast with the $10^{-3}$-$10^{-4}$ M present in organic or aqueous media. So the photoinitiated polymerization selectively retarded at the surface [3].

Another group in this study used one bottle technique single Bond Universal (3M ESPE) which is seventh-generation bonding systems, the “all in one” adhesives that combine etch, prime, and bond also contain silane in a single solution. This adhesive category was introduced in late 2002.

The ‘traditional’ dentine adhesives resin-based using a separate tooth etching or conditioning agent, a primer and a bonding resin, meaning that the numerous steps of adhesive must be completed before placing the composite resin filling material. The potential exists with each step, for blood or saliva contamination, the effects of humidity, or time incorrect application, which all of them can have a detrimental effect on the bond and the restoration life span [4-6].

To overcome this problem, introduced resin-based adhesives by several manufacturers that the separate steps have been combined together such as etching, priming and bonding, into one process. The aim of these ‘All-in-One’ systems is to reduce some of the technique sensitivity [7].

Silane coupling agent presses a general formula of: $X$ - (CH$_2$)$_3$ - Si - (OR)$_3$ they are bifunctional molecules one of them is reactive with various in organic materials such as glass, metals, silica. While the other molecule reacts to various kids of organic materials or synthetic resin, for this reason silane coupling agent can be used to repair ceramic as well as composite fracture or defect [8].

Also, another group using a diamond bur to make the surface roughness for the superfacial layer of the composite before place added increment layer this with out oxygen layer polymerization inhibiter. The last group cured the first layer of composite covered with celluloid strip to prevent formation of oxygen inhibiter polymerization layer.

**Materials and Methods**

This study composed of four groups and each group composed of 20 composite blocks prepared according to group construction procedure condition. The block prepared at dimension: (length: 3mm, width: 3mm, thickness: 2mm).
Then the first mold of heavy body is surrounded by another layer of heavy body impression material to construct another mold of a heavy body that are larger than first mold and the first mold fit inside it and have the same opening in the center to construct the second layer of a composite block which fit to first layer of composite figure 4.

The composite material used in this study was 3M ESPE Nano Hybrid Z250XT and the shade was B2 figure 5. Then Ash no. 6 used for the application first layer of composite material into the mold figure 6.

Using The VALO Cordless curing light has multi-wavelength (395 - 480nm) for 10 Sec. Complete set of first block composite layer according to group construction procedure condition.

After that the groups are divided according to the following:

*First group: Oxygen - polymerization inhibited specimens (20 block) of composite blocks are prepared by placing the first layer of composite in the heavy body mold, then adapted by ash 6 without placing anything on the surface of each block of composite before curing for 10 Sec figure 7. Then, the second layer composite applies and cured for 10 Sec figure 8.

*Second group: Inhibition formed of Oxygen- polymerization inhibited specimens (20 block) of composite are prepared by placing the first layer in the heavy body mold, then adapted by ash 6 then placing the celluloid strip on the surface of each block of composite before curing for 10 Sec figure 9. Then, the second layer composite applies and cured for 10 Sec.

*Third group: all in one adhesive system (one bottle\self etching 3M ESPE single bond universal adhesion material which
contained silane) specimens (20 block) of composite are prepared by placing the first layer in the heavy body mold and adapted by ash 6 then 3M ESPE single bond applied to the upper surface of the cured composite block and cured for 20 Sec figure 10. Then, the second layer composite applies and cured for 10 Sec.

*Four group* grinding specimens (20block) of composite: in this group blocks are prepared by placing the first layer in the heavy body mold, then adapted by ash 6 then no strip was used. The surface of the cured composite layer was grinned with a diamond bur by using a turbine to make the surface rough of each specimen for 10s at high speed with constant water spray figure 11. Then, a second layer composite applies and cured for 10 Sec.

Using the Light Emitting Diode (LED) VALO Cordless curing light which has multi-wavelength (395 - 480nm) for producing the high intensity light that produce polymerizing light cure composite materials figure 12. The 3M composite material cured at 400-500nm wave length, which required 10 sec to completely cure.

After completing the blocks we measure the union of these two increments composite, because incremental placement techniques are recognized as a major factor in the reduction of shrinkage stresses.

Then shear bond strength test was used to perform mechanical trials which calculated by dividing the force apply during measurement by surface area and expressed in Mega Pascal (Mpa), while stereo- and scanning by electron microscopy (SEM) provided a mean to assess improvements in failure patterns and interface quality.

**Shear bond strength (μSBS) testing**

Each specimen contains two composite increments bonded together was secured by tightening by prasser closed to the acrylic base that the increment embedded in it, on to the the Universal testing machine fixed compartment, with a load cell of 5N. The other composite increment aligned with the testing machine upper movable compartment loading axis.

The tensile mode with shearing load of force was applied at a crosshead speed of 0.5 mm/min via the testing machine figure 14.

In order to produce a shearing force that resulted in debonding of the two increments the relatively slow crosshead speed was selected. The load required for debonding was recorded in Newton and the data were recorded using computer software figure 15. To express the bond strength in MPa the load at failure (Newton) was divided by bonding area (mm²). The results were collected, tabulated and statistically analyzed.

**Results**

The shear bond strength test was calculated by dividing the force by surface area and expressed in Mega Pascal (Mpa). The shear bond strength for each one of the four groups show in the table (1):
The mean result of strip group has a highly significant difference from mean results of direct and bond groups.

The mean result of grinding group has a highly significant difference from mean results of all groups.

The mean result of direct group has non significant difference from mean results of bond group.

The mean result of grinding group has non significant difference from mean results of bond group.

Discussion

In the current study, to understand the compares between the shear bond strength of two composite layers in a four groups, we investigate the highest mean result among the groups in direct group was 32.14 (Mpa) that's referred to the Bonding between two composite layers of materials polymerized with radical polymerization is achieved in the presence of an oxygen-inhibited layer of un-polymerized resin. These undesirable reactions of photo-initiated polymerization of resin will reinforce the union between two increments of composite.

Li J. concluded that fresh composite which is covered by an oxygen inhibition layer easy to bond, because the uncured surface layer a covalent bond is established with the newly applied composite material [9].

The mean result of bond group was 30.75 (Mpa) which is the second highest result among the groups because the presence of silane in one bottle technique which is bonding systems (3M) seventh-generation the “all in one” adhesives that combine etch in a single solution prime, and bond.

The Silanes is adhesion promoters that contain two different reactive functional groups that can react and couple with various inorganic and organic materials. Silane coupling agents also increase the bond strength of coatings and adhesives as well as their resistance to humidity and other adverse environmental conditions.

Hisamatsu, et al. in 2002 They found that regardless of material variation the combined use of a silane primer and bonding agent generally showed the greatest magnitude of bond strength.

No significant differences were observed between the first and second group as highest shear bond strength between two increments of composite.

The last and lowest shear bond strength two groups are grinding group 19.67 (Mpa) and strip group (13.73 (Mpa), and these groups are significant difference with the highest mean shear bond strength (direct groups and bond group).

Tabatabaei, et al. in 2004 They concluded that for repair of an aged composite restoration the best surface treatment could be used of diamond bur with silane.

The mean result of grinding group was 19.67 (Mpa) which is higher than the mean result of strip group which was 13.73 (Mpa) because surface roughening by burs cause increase mechanical micro-retention This process might have associated with exposure of filler particles of the resin composite disc [10] while using strip result in smooth surface and this reduces mechanical.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Mean ±SD</th>
<th>Sig.</th>
<th>L.S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>32.14±1.14</td>
<td>0.000</td>
<td>1.811</td>
</tr>
<tr>
<td>Bond</td>
<td>30.75±1.854</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strip</td>
<td>13.73±1.301a,b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grinding</td>
<td>19.67±1.919a,b,c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SPSS. ver. 21 statistical software for window was used to analyze data. One way ANOVA (F-test) was used to detect the significant differences between groups. LSD was used to compare mean differences between each two groups (multiple comparison). P≤0. 01 was considered to be significant at 1% Table (2).
micro-retention also because the absence of oxygen inhibiter layer.

**Conclusion**

In conclusion, we showed that the presence of the oxygen-inhibited layer will achieve maximum shear bond strength of the composite increment with newly cured composite, in opposite the increment composite when applied on the composite that done with the celluloid strip or celluloid drown has a weakest shear bond strength, the bond with silane will enhance the shear bond strength.

The increment technique is the most recommended technique in a composite application, and during this technique the dentist may need to use a celluloid strip or correction grinding of the composite so should be applied a bond with silane if necessary to added additional increment of composite.

**References**


