Tensile Bond Strength of Three Dual-Cure Bonding Systems

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continuing education TDJ JOURNAL EXAM #24

ABSTRACT

OBJECTIVES: The purpose of this study was to test and compare the tensile bond strength of three dual-cure bonding systems on dentinal surfaces.

METHODS: Scotchbond MP Plus (3M Dental Products, St. Paul, MN 55144-1000), Allbond 2 (Bisco INC. Itasca, IL 60143) and Prime & Bond 2.1 Dual Cure (DENTSPLY Caulk, Milford, DE 19963-0359) were the three agents tested following manufacturer's instructions on flat dentinal surfaces. A total of 60 teeth were obtained, prepared and stored in distilled, deionized water prior to testing. Twenty teeth were distributed randomly to each bonding agent product. Ten of the 20 were light-cured and the other 10 were activated chemically, thereby creating six experimental groups. "Enforce" (DENTSPLY Caulk) resin cement was placed in a cylinder on the bonding agent interface in all 60 teeth. A pull test was performed using an Instron machine (Instron Corp., Canton, MA 02021) at a speed of 1mm/min and under continuous load until failure.

RESULTS: This study demonstrated that no significant difference existed among the means of the six sample groups involved when they were compared against each other using two-way ANOVA ($p<0.05$). Yet, when comparing light-cured samples as a group, versus chemically-cured samples, light-cured samples produced a significantly stronger bond. When comparing adhesive systems, regardless of the cure method, Scotchbond MP Plus resulted in a significantly stronger bond than Allbond 2. When only comparing chemically-cured samples, Scotchbond MP Plus was significantly stronger than Allbond 2. Prime & Bond 2.1 was not significantly different than Scotchbond MP Plus or Allbond 2 regardless of cure type. No difference existed when comparing only light-cured samples.

CLINICAL RELEVANCE: The bond strengths of adhesive systems are critical for the dentist in deciding which product to purchase to ensure the restoration will be a long-lasting one.

Introduction

Long-lasting bonds between dentin and restorative materials are crucial esthetically, as well as clinically, to the success of the restoration. Dentinal adhesive bonding agents are utilized to gain retention of composite restorations.

Removal of the smear layer with a priming or conditioning agent aids in this process because the bonding agent penetrates the remaining dentin surfaces.[1,2] Once the smear layer has been removed, resin penetrates the dentin surface and resin tags are created into the dentinal tubules to obtain micromechanical retention by bonding to the collagen component of the dentin.[3,4] The area that is created where the resin intermingles with the dentinal surface is called the hybrid zone.[5] Results of previous studies have demonstrated that a strong bond is established in the dentin by increasing its permeability.[6] This bond will minimize the size of any gap present between the dentin surface and restorative material. This is significant because recurrent caries, irritation to the pulp and leakage will be minimal.[7]

Bonding to dentin is more complicated than bonding to enamel due to the high organic and water content of the dentin.[8,9,10] In addition, greater regional variability of dentin wetness has been shown in occlusal regions compared to proximal or facial regions.[11] The low permeability of dentin and its surface moisture are often deemed to be the cause of failure or low adhesion values.[6] Due to the presence of phosphoric acid in etch solution, new generation bonding agents are aggressive toward dentin and the smear layer. The bonding agents on the market today add hydrophilic agents to the primer and alter the surface of dentin by binding to collagen and increasing its permeability by creating the so-called hybrid zone. Permeability is important when discussing the interlocking of the dentinal tubules with resin tags to obtain maximum surface retention.[10] The

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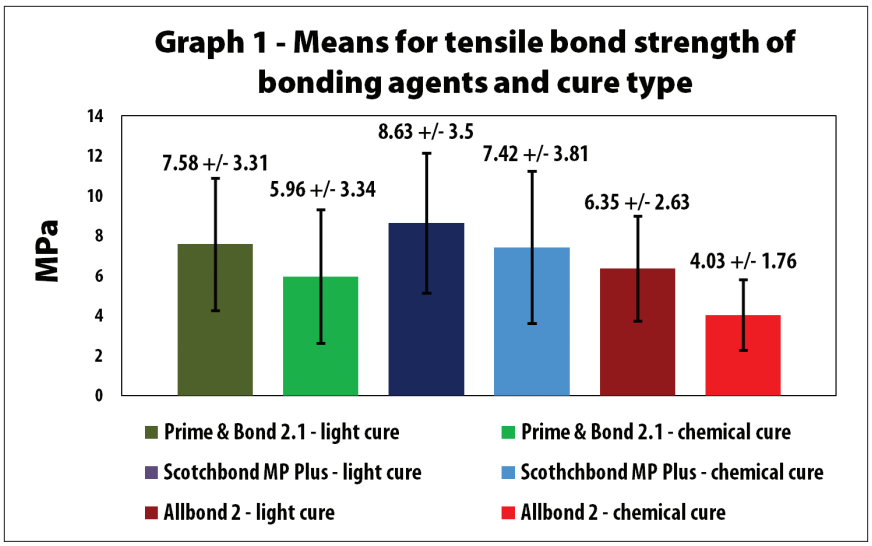
None of the authors reported any conflict of interest disclosures.

penetration of resin into dentin prohibits resin shrinkage during polymerization, thus preventing open margins.[12,13]

The goal of this study was to effectively evaluate and compare the tensile bond strength of three dual-cure bonding agents on human dentinal surfaces using light or chemical cure.



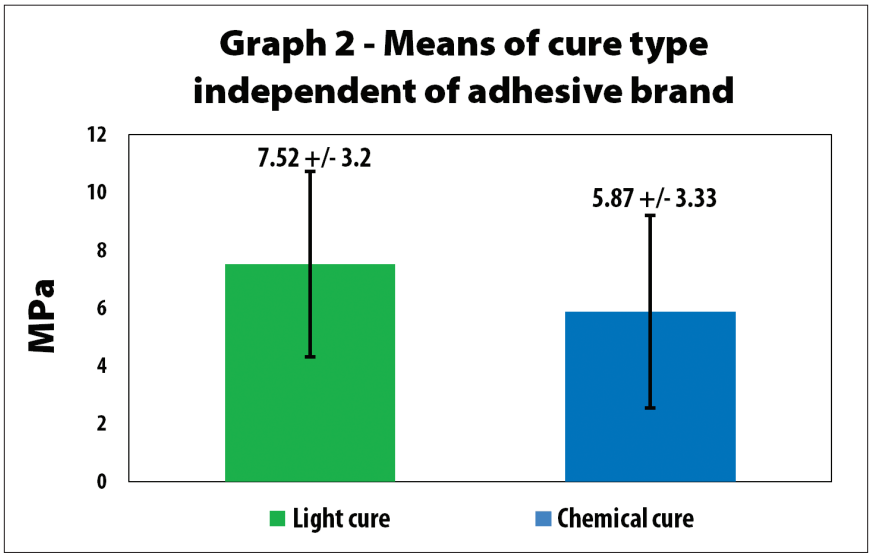
Materials and Methods

A total of 60 teeth, each with a minimal area of 7mm in diameter on a facial surface free from restorations or irregularities were selected. Twenty teeth were randomly assigned to one of the following dentin bonding agent groups: Allbond 2 (Bisco INC., Itasca, IL 60143), Scotchbond MP Plus (3M Dental Products, St. Paul, MN 55144-1000), or Prime & Bond 2.1 Dual Cure (DENTSPLY Caulk, Milford, DE 19963-0359). The roots were sectioned from the crown 1mm apical to the CEJ using a separating disk with a low-speed handpiece. Throughout the experiment the teeth were stored in distilled, deionized water in order to prevent desiccation.

A circle with a 7 mm diameter was drawn in pencil on each tooth at the height of contour. Thirty plastic containers with dimensions of 1.75 in x 1.0 in x 0.6 in were obtained. Two teeth were placed at opposite ends of each container and secured with a small amount of boxing wax. The boxing wax allowed the height of contour to be placed closer to the top of the open end of the container. The methyl- and polymethyl-methacrylate of Trim (Harry J Bosworth Co., Skokie, IL 60076) acrylic were mixed in a paper cup to a liquid consistency. The acrylic was poured into the plastic container holding two teeth, allowing only the 7 mm circle to be exposed above the acrylic. This process was repeated for the remaining 29 containers, which were immediately returned to the distilled deionized water. After the acrylic had self-cured, the samples were removed from the plastic container and a diamond saw was used to separate the two teeth, so that each sample block had a width of 0.5 in. The purpose of creating this block for each tooth was to aid in its handling during preparation and to act as a holder for the tooth which would not fracture during testing in the Instron machine (Instron Corp., Canton, MA 02021).

Each block had the 7 mm circle at the height of contour exposed from the acrylic base at this point. A sander was used with 36, 320 and 400 grit sandpaper to expose and smooth the dentin to a flat surface. At least a 5.5mm diameter circle of dentin was obtained prior to continuing with the experiment.

Twenty teeth were distributed to each manufacturer group, 10 cured via curing light and ten cured chemically. The following procedures are per manufacturer's instructions:



Prime & Bond 2.1 Dual Cure (light-cure)

The dentin surface was etched with a 34% phosphoric acid for fifteen seconds and then rinsed for fifteen seconds. The surface was blot-dried with a cotton roll to remove pooling of solutions on the dentin surface. The primer/adhesive was generously brushed onto the surface and allowed to remain on the surface for 20 seconds and then gently air-dried to remove excess solvent for five seconds leaving a glossy surface. Next, the primer/adhesive was light-cured for 10 seconds. A second coat of primer/adhesive was applied immediately and was air-dried for five seconds and light-cured.

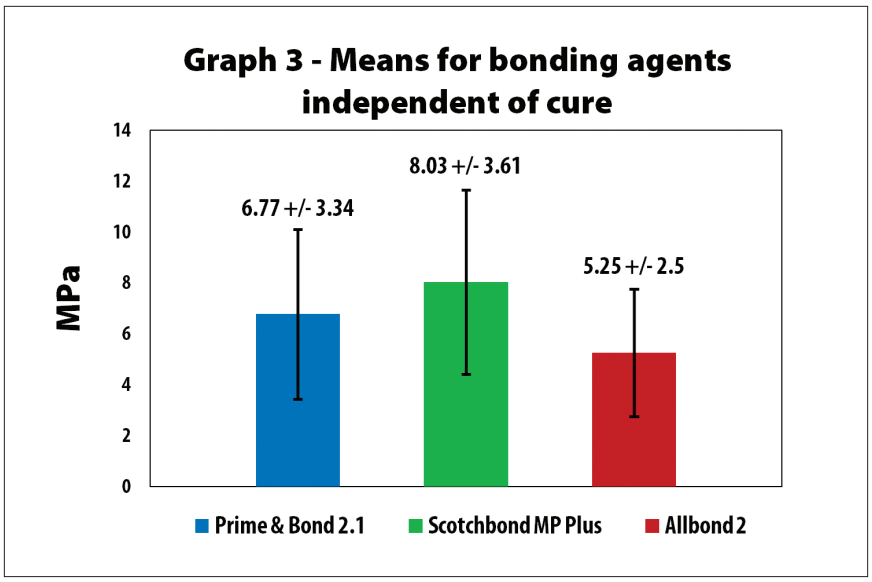
Prime & Bond 2.1 Dual Cure (chemical-cure)

The procedure was the same as above except that the primer/adhesive was mixed with an equal amount of Self-Cure Activator in a mixing well for two seconds prior to application onto dentin. The surface was air-dried for five seconds to achieve a glossy appearance, and no light was used to cure the primer/adhesive.

Scotchbond MP Plus (light-cure)

The dentin surface was etched and

rinsed, as with Prime & Bond, but was dried with a blast of air from a syringe for two seconds. The primer was brushed on the surface and then air-dried with a syringe for five seconds. The adhesive was then brushed on the dentin surface and light-cured for 20 seconds.



Scotchbond MP Plus (chemical-cure)

As above, the dentin surface was etched, rinsed and dried. The activator was brushed on the surface and air-dried with a syringe tip for five seconds. Next, the primer was brushed onto the surface and then air-dried with a syringe for five seconds. In a mixing well, equal amounts of adhesive and catalyst were dispensed and mixed. The adhesive/catalyst mixture was brushed onto the surface of the dentin.

Allbond 2 (light-cure)

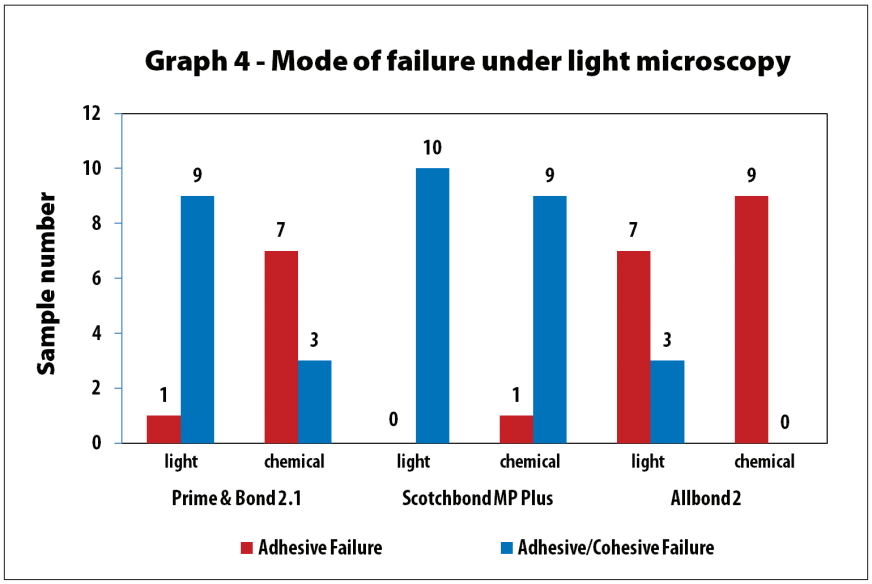
Thirty-two percent Phosphoric acid was used to etch the dentin surface for 15 seconds. The surface was rinsed and dried as with Scotchbond MP Plus. Equal amounts of Primers A and B were mixed in a mixing well. Five consecutive coats were placed on the dentin without drying between layers. The surface was dried for five seconds with an air syringe tip. The surface was glossy at this point. A thin layer of Dentin/Enamel Resin was brushed onto the surface and light-cured for 20 seconds.

Allbond 2 (chemical-cure)

The dentin surface was etched, rinsed and dried as above. The primer was brushed, dried and light-cured as above. An equal amount of Dentin/Enamel Resin and Pre-Bond was mixed in a mixing well, brushed onto the surface and air-thinned gently to remove excess solvent.

For all 60 teeth, a piece of a clear drinking straw 9 mm in length, 5.2 mm in diameter was placed onto the prepared surfaces of dentin. Sticky wax was flamed and used to hold the straw in place prior to placement of composite material. Equal amounts of Enforce Catalyst and Resin were mixed for ten seconds on a mixing pad and placed inside the straw. The Enforce was packed to ensure full contact with adhesives. A screw eye was placed in the center of the straw containing Enforce and held in place while the Enforce was light-cured for 20 seconds on each side of the cylindrical straw. The sample was allowed to sit on the bench top for five to six minutes to ensure cure of Enforce prior to moving the sample to a 37°C water bath for 24 hours. After 24 hours, the sample was removed from the water bath. The sticky wax was removed from the sample and a three-inch length of wrought wire was looped through the screw eye and attached to the Instron machine. The Instron worked at a speed of 1mm/min and force of 50N/V.

After testing the tensile bond strength, the samples were viewed under light microscopy to locate the layer through which the fracture occurred.



Results

The means and standard deviations for all six sample groups are summarized in **Graph 1**. A two-way analysis of variance (ANOVA) ($p<0.05$) demonstrated that no significant difference existed among the means of the six sample groups involved when they were compared against each other. When comparing light-curing methods using a one-way ANOVA ($p<0.05$), light-cured samples produced a significantly stronger bond than chemically-cured samples (**Graph 2**). The mean for light-cured samples was 7.52 MPa, while the mean for chemically-cured samples was 5.87 MPa. A one-way ANOVA ($p<0.05$) testing the adhesive type independently of cure type found that Scotchbond MP Plus (8.03MPa) was significantly stronger than Allbond 2 which had a mean of 5.25MPa (**Graph 3**). No difference exists among light-cured adhesives, but a significant difference does exist between Scotchbond MP Plus (7.42 MPa) and Allbond 2 (4.03MPa)

when considering only chemical-cure.

All of the samples were observed under light microscopy to evaluate the location of fracture during testing. Of the 59 samples tested, 25 fractured between the dentin and adhesive interface, and 34 fractured in a jagged manner between the dentin/adhesive inter surface and cohesively within the adhesive/composite layer.

Discussion

Bonding to dentin, due to high organic content, is a very technique sensitive task. Manufacturers are improving their bonding agents to simplify the procedure in order to minimize operator error.[14] The active ingredient in the etchant, which removes the smear layer created by preparation of the tooth, is Phosphoric acid. If this etchant remains on the surface for an overextended period of time, the dentinal tubules will collapse due to demineralization. In contrast, if the etchant is removed too soon, the smear layer will still be partially intact; however, the presence of the smear layer may not influence early bond strength values.[15,16,17,18,19] The primer must also be properly placed onto the surface. After removal of any excess, the remaining surface must be shiny. If the surface is not shiny, then either the primer was not allowed to remain on the preparation for an adequate time, or the preparation was desiccated during the drying process and the primer was removed.

When analyzing the light-cured samples against those chemically-cured, the light-cured group proved to be significantly stronger than the chemically-cured group. In fact, in all cases each manufacturer's light-cured group produced a stronger bond than the chemical-cure. This may be due to the fact that the light-cure better prepares the surface for composite resin, whereas the self-curing liquid mixed with adhesive has a greater chance to be displaced prior to composite placement.

The priming procedure of Allbond is extensive because it requires particular attention to each of the five separate coats of primer that needs to be placed prior to air-drying with a blast of air. This is in comparison to Scotchbond which requires one coat to remain on the surface for 20 seconds and then air-dried for five seconds. Although Prime & Bond 2.1 is a fifth generation adhesive, meaning the primer and adhesive bottles are combined to a "one-step" procedure, it did not prove to be more beneficial (7.58 MPa) to the strength of the bond than the fourth generation Scotchbond MP Plus light-cure whose bond strength was 8.63 MPa (**Graph 1**).

The strongest bonds fractured in a jagged manner across the dentin/adhesive/composite layer (**Graph 4**). In fact, in the case of Scotchbond MP Plus light-cure, all ten fractured in this manner. The second strongest bond strength belonged to Prime & Bond 2.1 light-cure, where nine fractured as mentioned above as did Scotchbond MP Plus chemical-cure, the third strongest bond. As the average bond strength decreased, more samples fractured cleanly between the dentin/adhesive layer. This is demonstrated with Allbond 2 chemical-cure (the weakest mean bond strength) where all samples fractured cleanly in this manner.

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Questions for Continuing Education Article - CE Exam #24

1. Dentinal bonding agents for restorative materials are utilized to:
   a. gain retention for composite restorations.
   b. prevent fracture of alloy restorations.
   c. treat pulp exposures.
   d. maintain color accuracy.

2. A priming or conditioning agent:
   a. removes the smear layer.
   b. increases sensitivity.
   c. primes the Sodium pump.
   d. functions as an anodyne.

3. Once the smear layer is removed, resin:
   a. penetrates the dentin surface.
   b. creates resin tags.
   c. obtains micromechanical retention.
   d. all the above.

4. The area where the resin intermingles with the dentinal surface is called:
   a. the twilight zone.
   b. the zone on inhibition.
   c. the permeability zone.
   d. the hybrid zone.

5. Why is bonding to dentin more complicated than bonding to enamel?
   a. It is more difficult to see.
   b. Dentin has high water and organic content.
   c. Because dentin has high permeability.
   d. Because enamel is hydrophilic.

Publication date: Fall 2010. Expiration date: Fall 2013.

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