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Evaluation of Shear Bond Strength of Composite Resin Bonded to Dentin with Three Different Adhesive Systems

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Key words
shear bond strength , dentin, adhesive, solvents.

Abstract

Aim of the study to measure the shear bond strength of composite resin bonded to dentin with three different adhesive system.

The buccal surfaces of 30 non-carious, intact, extracted upper premolar (Freshly extracted for orthodontic treatment), were grinded with 600 grit silicon carbide paper to expose dentin surface. the samples were divided into three groups: G1, 10 teeth were bonded with an acetone-base total-etch Prime&Bond NT G2, 10 teeth were bonded with an ethanol-base total-etch Excite. G3,10 teeth were bonded with an ethanol-and water-base total-etch Schotchbond 1. Shear bond strength is determined by using Instron testing machine.

Results showed that excite adhesive system has statistically high significant increase in shear bond strength than Schotchbond 1.
As conclusion; the lack of water in the adhesive may play a more important role than the type of solvent itself.

Introduction

Effective bonding to dental substrates has been one of the major goals in restorative dentistry through the last decades. [(12)] Dentinal adhesion has been more difficult and less predictable because of its complex histological structure and the variable composition of dentin. In addition, the formation of a smear layer from dentin cutting decreases the permeability of resin into dentinal tubules. [(1)] The formation of a hybrid layer and resin tags is essential to the establishment of a strong bond between resin and dentin. 0ne way of achieving this is by complete dissolution of smear layer and the demineralization of intertubular and peritubular dentin, resulting in an exposed collagen matrix that is subsequently infiltrated by resin that polymerizes. [(2)] All current adhesive systems are designed to be hydrophilic and contain resin monomers dissolved in acetone, ethanol, water or some combination of these solvents. Water and organic solvent, also known as "water-chasers", play an important role in wet bonding. These components are responsible for water displacement from the collagen network and infiltration of resin monomers intospaces previously occupied by water. [(3)] The aim of this study is to measure the shear bond strength of composite resin bonded to dentin with three different adhesive systems(prime& Bond NT, Excite, and the Schotchbond 1).

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Material and methods

Construction of acrylic blocks

The roots of the teeth were sectioned by diamond disc with the workshop hand piece at the cemento-enamel junction.The acrylic block construction was made by using a brass mold with an internal stone mold of 24, 20, 16 mm dimensions. A depression (half ball) was made at the base of one stone mold of 6 mm diameter& 2 mm depth. The separating medium was varnished to the walls of the mold then the sample was placed at this depression with the buccal surface to be treated faced downward & wax was used to fill the remnant space, the self cure acrylic was loaded into the mold & after completion of polymerization, the two parts of mold were separated &excess acrylic was removed.)

Exposing the Dentin

2 mm of the buccal surface of the blocked teeth were grounded to obtain flat superficial dentin surface with 600-grit silicon carbide paper fixed on rotofix machine under a stream of running water . To ensure that only 2 mm removed from the samples, the samples were positioned in the scale, so that it will only be moved 2mm after it first touches the grit. Then the samples were stored in distill deionized water(DDW) at 37 C° for one hour. [(4)]

Bonding Procedure

The dentin surfaces of each tooth was washed with (DDW) spray for 15 seconds then dried with an air syringe for 5 sec. the ground surface was examined in stereomicroscope by two examiners to ensure that no enamel remnants were left on the ground dentin surface. Then apply total etch on the dentin surface and allow a reaction time of 15 seconds. After that , rinsed for 15 seconds, excess water were removed by the application of gentle air steam(free of oil) for 2 seconds at a distance of approximately 1 cm from the preparation surface (the dentin surface should be slightly moist).A paper puncture was used to make a hole in a piece of adhesive-paper with 4mm diameter holes to delineate a circular treatment area for dentin bonding. Then these pieces were placed on the buccal surface of each tooth and the exposed dentin surface was encircled by the hole. [(5)]The bonding agents were applied according to manufacturer instructions.

G1 Pr: Application of Prime&Bond® NT bonding system.

Dispense Prime&Bond® NT directly by a fresh applicator or by a diposable brush. Immediately apply ample amounts of Prime&Bond® NT onto thoroughly wet all tooth surfaces. This surface should be saturated which may necessitate additional application of Prime&Bond® NT. Then leave the surface undisturbed for 20 seconds. Remove solvent by blowing gently with air from a dental syringe for at least 5 seconds. Surface should have a uniform, glossy appearance. Then applying Light-cure for 10 seconds.

G2 Ex: Application of Excite bonding system.

A generous amount of excite was applied on dentin surface using a Vivadent applicator. Gently agitating the adhesive onto all prepared dentin surface for 10 seconds, then evaporating any remaining solvent with a gentle air for 3 sec. at a distance of approximately 5mm from the preparation surface, and then cured with light cure for 20 seconds at a distance of approximatelly1 mm from the preparation surface. The dentine surface should have a visible glossy appearance.

G3 Sc: Application of Schotchbond 1 bonding system.

Using a fully saturated brush tip for each coat. Dry gently for 5 seconds. Apply 2 consecutive coats of bonding to etched dentin. Light cured for 10 seconds.

Placing the Restoration

Application of the composite was done for all specimens of groups according to manufactured instructions and using device specially designed for the standardization of the composite applications. The device composed of a metal board with a fixed handle to hold the light cure gun in a way that the tip comes in a 90˚ angle to the sample .also there is a circular movable base on which the sample was placed.Near the base there is a holder supporting a one kilogram weight to which a 3.9mm in diameter, metal covered with plastic, condenser attached to it. There is a screw indicator in the upper end of the condenser which has a diameter wider than the plastic tube. 2 mm of composite cured for 40 seconds (each increment 20 seconds) (according to manufactured instructions).The bonded teeth were stored in 37°C distilled water for 24hrs before being tested. [(6)]

Aging &Thermo Cycling

Thermal cycling allows bonded specimens to extreme temperatures which simulate intraoral condition. Therefore, all specimens were subjected to 300 thermal cycles using two water baths set at 5 c˚ &at 55c˚ & with dwell time of 30 seconds in each bath with a transfer time of 5 seconds [(7)], using thermo cycling machine. The specimens were again stored in(DDW) at 37C˚until testing.

Testing Procedure (Shear Bond Test)

Shear bond strength was evaluated with Instron testing machine. Using a stainless steel chisel-shaped rod, this was used to deliver the shearing force with a cross head speed of 0.5 mm/min (ISO TR 11405). The load cell was set at 100 Kg.The tested specimens were placed in a specially designed acrylic block holder which was placed on the testing machine. The samples was held in a vertical position in such a way that the long axis of the chisel-shaped rod was parallel to the flat prepared bonding site and perpendicular to the long axis of composite cylinder.The chisel end of rod was positioned at the interface between the sample surface and composite cylinder. The specimens were loaded until they fractured. The forces were recorded in Newton which has been divided by the surface area 12.56 mm^2 to obtain shear bond strength calculated in Mpa.

Shear bond strength (SBS) =force/ surface area

Surface area = R^2 x π , π = 3.14 , R = Radius = 2mm

Results

The mean, standard deviations and the standard of errors of the shear bond strength with the minimum and maximum values of each group are showed in the table (1).Figure (1) shows the mean shear bond strengths of phosphoric acid etched dentin with three adhesive systems of different solvents. Excite (ethanol-base) adhesive system shows the highest bond strengths.Statistical analysis of data revealed that shear bond strength for Excite (18.90±2.932 MPa) were significantly higher ($P<0.05$) than Schotchbond 1 (14.62±2.925 MPa) adhesive system for dentin etched with phosphoric acid.There was no statistically significant difference between Excite (18.90 ±2.932 MPa) and Prime&Bond NT (16.73±3.20 MPa). Also, there was no significant difference between Prime&Bond NT (16.73±3.20 MPa) and Scotchbond 1 (14.62±2.925 MPa) as shown in table (2).Both adhesive without water (Excite and Prime & Bond NT) resulted in statistically similar mean SBS. While water-based adhesive (Schotchbond 1) resulted in lower mean SBS.

Discussion

The efficacy of dentin adhesives seems to be improved by the addition of high vapor pressure organic solvents to the adhesives' chemical formulations. Acetone and ethanol are commonly used solvents found in the majority of current bonding systems. These chemical agents function as "water-chasers" and solubilize resin components. They increase the wettability

of the dentin substrate by the bonding systems and help to replace water in the acid-etched, rinsed dentin surface with hydrophilic resin monomers. High bond strengths are obtained with bonding agents dissolved in high vapor-pressure solvents such as acetone or ethanol when acid-etched dentin is left visibly moist. [8]In this study fifth generation one-bottle dentin bonding systems was used that prevent collagen collapse of demineralized dentin and make the use of adhesive material more reliable. Three different total-etch dentin adhesives was used in the present study that contain organic solvents (acetone or ethanol) and small hydrophilic monomer Schotchbond 1 and Excite contain HEMA, where as Prime & Bond NT contains small hydrophilic molecule.Excite (ethanol-base, water free) adhesive system has resulted in bond strength higher than for Schotchbond 1 (water-andethanol-based) adhesive in the both group (laser and acid). Water-based adhesives result in lower bond strengths than the adhesive with acetone or ethanol. This may be explained by Kanca [9]and Manksgaard [10] who considered that acetone and alcohol effectively displace water and are therefore better facilitators of resin primer infiltration as compared to water based adhesive systems. Also, it was speculated that the water left by the water-based adhesive might prevent the complete polymerization of the adhesive inside the hybrid layer. [11]Carvalho et al., 2003 speculate that, during evaporation of the solvent in the HEMA/water specimens, the more complaint matrix shrank, reducing the width of resin – filled interfibrillar spaces in the hybrid layer, decreasing the resin uptake, and lowering the bond strength obtain in the HEMA/water group. Conversely, when ethanol was used as solvents, although the matrix may have expanded somewhat less, that expansion was sustained after solvent evaporation, because of these water-free solvents stiffened the matrix, allowing for better resin infiltration.[6]The present study found statistically similar results for Excite and Prime & Bond NT which in agreement with Lyra et al., 2002[12]. However, at least one in vitro study found higher bond strengths for Excite than for Prime & Bond NT, both in shear and microtensile test. [13]The organic solvent (acetone or ethanol) displace water from the moist collagen network, thus promoting the infiltration of resin monomers through the nanospaces of dense collagen web. [14] The resin replaces the water of the pores among the collagen fibers. These pores could serve as diffusion channels for subsequently applied monomers, of single bottle dentin bonding systems, thus improving the resin impregnation of the demineralized dentin web.This similarity in the results of Prim&Bond NT and Excite, suggests that the lack of water in the adhesive may play a more important role than the type of solvent itself. [15]

Conclusions

1.There was a similar results between Excite adhesive system (ethanol solvent system) and Prime&Bond NT (acetone solvent system).

2.The shear bond strength of Excite which represent the ethanol-base adhesive system is significantly more than that of Schotchbond 1 which represent the water and ethanol-base adhesive bonding system.

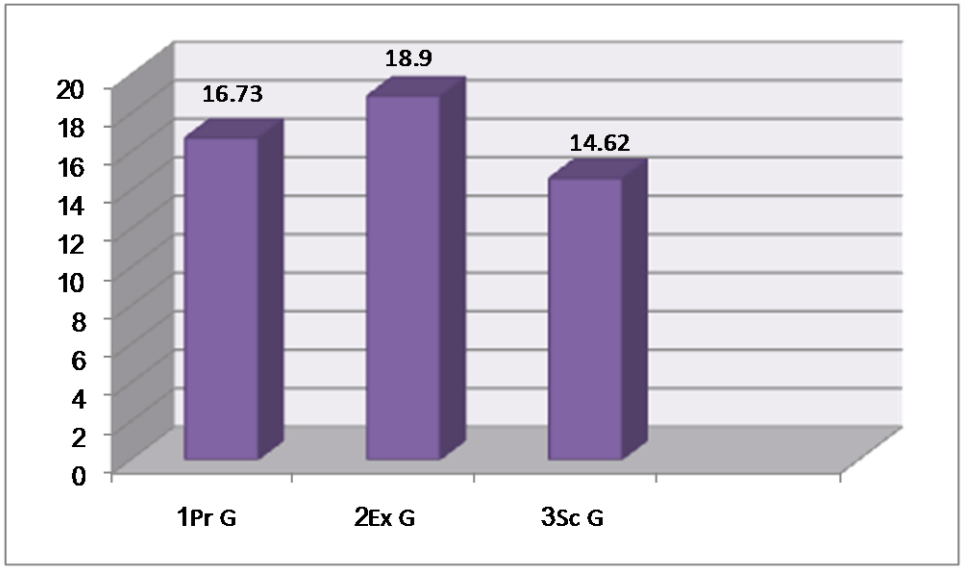

Fig. (1):- Graphical presentation of mean shear bond strength values for all the groups.

Table (1):- Descriptive statistic of shear bond strength values in Mpa. For all Groups.

Groups	Mean	S.D	S.E	Min.	Max.
G1Pr	16.73	3.20	1.01	11.80	22.00
G2Ex	18.90	2.932	0.927	14.10	23.60
G3 Sc	14.62	2.925	0.925	10.10	18.50

Table (2):- Comparison between groups using ANOVA test.

Source	d.f	SS	MS	F-test	Pvalue
Between groups	2	91.60	45.80		
Within groups	27	246.42	9.13	5.02	0.014 S
Total	29	338.01			

SS: sum square
MS: mean sequare
S: Significant difference at level P < 0.05.

Table (3):- L.S.D between G2 subgroups.

Groups	Difference between means groups	L.S.D 0.05	L.S.D 0.01	Sig.
G1 Pr & G2Ex	2.17			N.S
G1 Pr & G3 Sc	2.11	2.77	3.74	N.S
G2Ex & G3 Sc	4.28			H.S

L.S.D: least significant difference
N.S: Non Significant difference at level P > 0.05.
H.S: Highly Significant difference at level P < 0.01.

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