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ORIGINAL RESEARCH

Bond Strength of Adhesive Systems with Different Solvents to Dry and Wet Dentin

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ABSTRACT

Aim: This study evaluates bond strength between dentin and composite using adhesives with different solvents to dry and wet dentin.

Materials and methods: Ninety bovine incisors were used; the vestibular surfaces were worn by the exposure of an area with a diameter of 4 mm of dentin. The specimens were divided into 6 groups, according to the type of adhesive used and hydratation stals: Group SB-wet: Single Bond 2 in wet dentin, Group SB-dry: Single Bond 2 in dry dentin, Group SL-wet: Solobond M in wet dentin, Group SL-dry: Solobond M in dentin dry. Group XP-wet: XP Bond in wet dentin, Group XP-dry: XP Bond in dentin dry. They were cut to obtain specimens in the shape of stick with 1 × 1 mm and subjected to microtensile test in universal testing machine with a cross speed of 1mm/min. The data were analyzed with ANOVA and Tukey's tests (5%).

Results: ANOVA showed significant differences for surface treatment and interaction, but no difference was found for adhesive factor. The Tukey's test showed that the samples with wet dentin shown higher values of bond strength.

Conclusion: The adhesive did not influence in the bond strength. The groups with wet dentin showed higher values of bond strength than groups with dry dentin.

Keywords: Dentin, Bond strength, Adhesive systems.

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INTRODUCTION

The most part of clinical success of a restorative dental procedure is based in the sealing between resin material and dental surface. To obtaining this goal is related to the ability of the composite restorative resist to immediate mechanical stress due to its polymerization shrinkage and forces,[1,2] or mechanical stress, related to the masticatory pathophysiological.

The etching of dentin promotes the removal of the smear layer, smear plug and demineralization of peritubular and intertubular dentin. After washing with water, approximately 70% of the volume of demineralized dentin becomes full of water that occupies the place of the mineral portion removed by etching.[3] This is responsible for maintaining the collagen expanded, maintaining the porosity necessary for the penetration of the adhesive system in the demineralized dentin.[3] However, if the acid etched surface is dried with a strong air blast, water that support the collagen network evaporates causing the collapse of collagen fibers, promoting a reduction of space available for the infiltration of the adhesive system.[3]

Many studies showed that the adhesion to dried dentin results in a significative reduction of the bond strength,[4-6] indicating thus certain degree of wetness must be accept.

However, some studies suggest that the type of solvent present in the adhesive system may influence the degree of penetration of resin monomers even when applied on dry dentin.[7]

The monomers of adhesive systems are carried by a solvent which is usually either water, ethanol, acetone, or a combination of those.[8] Especially acetone-based systems require a moist dentin surface after acid etching in order to enable the monomers of the bonding system to completely penetrate the decalcified area. A collapse of the exposed collagen network due to overdrying would seriously lower bond strengths and increase the risk of postoperative symptoms.[9-11]

A new type of solvent for adhesives, namely tert-butanol was introduced for XP Bond. Tertiary butanol is claimed to be totally miscible with water and polymerizable resins. This property may promote the interaction of the adhesive with a moist substrate and allow for an increase in the resin content of the bonding solution [Technical Bulletin, Dentsply DeTrey Kostanz, Germany].

Based on this, the objective of this study was to evaluate the effects of hydration states of the dentin surface on bond strength using adhesive systems with various kinds of solvents.

MATERIALS AND METHODS

Ninety freshly extracted bovine incisors were used. They were cleaned and stored in deionized water inside a freezer at –18°C until use. Initially, the roots were sectioned with steel flexible diamond disk in the hand piece at the cemento-enamel junction. Only the tooth crowns were used. The buccal surfaces were worn with 400 grit abrasive paper in a polishing machine (DP-10, Panambra, São Paulo, Brazil) under cooling with water, exposing a dentin area with 4 mm diameter. The remaining dentin thickness was standardized in 2 mm. The teeth were embedded in self-cured acrylic resin using a silicon mold. The smear layer was standardized using 600 grit sand paper.

The specimens were randomly assigned according to kind of surface hydratation of dentin and adhesive system used:

- *Group SB-wet:* Adper Single Bond 2 (3M ESPE) applied on wet dentin surface;
- *Group SB-dry:* Adper Single Bond 2 (3M ESPE) applied on dry dentin surface;
- *Group SL-wet:* Solobond M (VOCO) applied on wet dentin surface;
- *Group SL-dry:* Solobond M (VOCO) applied on dry dentin surface;
- *Group XP-wet:* XP Bond (Dentsply) applied on wet dentin surface;
- *Group XP-dry:* XP Bond (Dentsply) applied on dry dentin surface.

All teeth received total-etching on their surface, applying 37% orthophosphoric acid (VOCO, Germany) for 15 seconds, and then, they were washed with water for 30 seconds. For the wet surface the excess of water was removed using a cotton wool with gently pressure. In order to obtain the specimens with dry dentin, the surface was dried using on air blast at 5 cm away for 10 seconds.

All the adhesives systems were used according to the manufactures instructions.

After adhesive systems application, was applied on each specimen to composite resin Filtek Z350 (3M ESPE). The resin was inserted in increments of 2 mm, with the help of a matrix of silicon with dimensions of 4 × 4 × 4 mm. Each increment was photocured using a halogen photocuring unit with power density of 400 mW/cm^2 (Ultralux, Dabi Atlante, Ribeirão Preto, São Paulo, Brazil) for 40 seconds. To complement the polymerization of the resin, the matrix was removed and the block was cured for 40 more seconds.

The specimens were stored in distilled water at 37ºC for 24 hours. The teeth were then sectioned perpendicular to the bonding surface using Labcut 1010 (Extec Technologies Inc., USA) under continuous water cooling to obtain rectangular resin-dentin beams. The saw was adjusted in steps of 1mm resulting in sticks with cross-sectional area around 1 mm^2.

The trade name, chemical composition and manufacturer of materials used are presented in Table 1.

The specimens were tested in microtensile device of the universal testing machine (DL-200 MF, EMIC, São José dos Pinhais, Paraná, Brazil), with a load cell of 10 kg at a speed of 1mm/min, according to the rules described in ISO TR 11405. The data, expressed in megapascal (MPa) were subjected to statistical tests using two-way parametric analysis of variance (ANOVA) and Tukey's test using a significance level of 5%.

RESULTS

In Table 2 are shown the results of ANOVA. It showed that there were significant differences of tensile bond strength between the techniques used for drying the surface, but there is no difference between adhesive systems.

Table 3 there is the result of the Tukey's test for the adhesive system. The values of bond strength are not statistically significant.

Table 1: Materials, manufacturers and their compositions

Name	*Manufacturer*	*Composition*
Vococid	Voco/Cuxhaven, Germany	37% orthophosphoric acid
Adper Single Bond 2	3M ESPE St. Paul, MN, USA	Bis-GMA, HEMA, dimethacrylate, methacrylate functional copolymer of polyacrylic and polytaconic acid, water, alcohol, photoinitiator.
Solobond M	Voco, Cuxhaven, Germany	Methacrylates, acetone, organic acid derivates and an organic, fluoride component.
XP Bond	Dentsply De Trey GmbH D, Konstanz, Germany	TCB resin; modified phosphate acrylic resin, UDMA, TEGMA, HEMA, stabilizers, ethyl-4-dimethylaminobenzoate, camphoroquinone, functionalized amorphous silica, t-butanol
Filtek Z350	3M ESPE St. Paul, MN, USA	Fillers of zirconia and silica size range 0.6 to 1.4 microns with primary particles of 5 to 20 nm, silica of 20 nm no-filler, resin bis-GMA, UDMA, TEGMA e bis-EMA. Inorganic load of 78.5%

Table 2: Results of ANOVA two-way

Factors	*Degree of freedom*	*F*	*p**
Adhesive system (AS)	2	2.72	0.0915
Surface treatment (ST)	1	32.45	0.0000
Interaction SA*TS	2	5.01	0.0074

*Significant differences

Table 3: Results of Tukey's test for adhesive system

Adhesive system	*Mean ± SD*	*Homogeneous groups*
XP bond	25.42 ± 8.33	A
Solobond M	24.79 ± 6.49	A
Adper single bond 2	22.90 ± 7.11	A

SD: Standard deviation

Table 4: Results of Tukey's test for surface treatment

Surface treatment	*Mean ± SD*	*Homogeneous groups*
Dry dentin	21.75 ± 6.99	A
Wet dentin	26.99 ± 6.88	B

Table 5: Results of Tukey's test

Group	*Mean ± SD*	*Homogeneous groups*		
XP wet	29.49 ± 8.25	A		
SB wet	25.88 ± 6.57	A	B	
SL wet	25.59 ± 5.44	A	B	
SL dry	23.99 ± 7.37		B	C
XP dry	21.35 ± 6.50		B	C
SB dry	19.82 ± 6.55			C

Table 4 notes the data by the Tukey's test on the dentin surface treatment. The groups that remained wet dentin showed values of bond strength higher statistically significant for groups with dry dentin.

Table 5 is shown result of Tukey's test for all groups. The interaction adhesive system and surface treatment of different between all groups.

DISCUSSION

Treatment that is given to the dentin surface before the restorative procedure is directly related to the success of restoration. During restorative procedure is important the maintenance of humidity. Clinically the humidity of the dentin surface may be modified according to the technique used for drying the structure. Many studies seek to relate the quality of the adhesion of the adhesives systems under different conditions of the surface of dentin.[4,6,7,12,13]

Dentin bonding still faces questions related to the appropriate humidity level for better hibridization, protection of the pulp and to seal adequately the cavity margins.[14-16] The morphology of the adhesive interface has been studied to identify hybridization patterns provided by several adhesive systems, under many different dentinal substrate conditions.[15,17] The collagen fibril mesh collapse, caused by dentin dehydration,[16,18] limits the possibility of the micromechanical retention of the adhesive system in primed dentin. However, if the meshwork is re-expanded, there is an improvement of the microtensile bond strength.[3]

In this study, the groups with dry dentin showed lower values of adhesion than the groups with moist dentin. This result differs from Pereira et al[19], the authors tested different levels of moisture of dentin, and the resistance values were higher in the group that received drying for 30 seconds with air blast and lower in the group that did not receive any of the drying surface.

Reis et al[5] found divergent results of previous research. In the study, the authors evaluated the bond strength immediately and after 12 months. The groups with wet dentin shown higher bond strength values than groups with dry dentin. After 12 months, there was significant statistic difference in relation to the technique of applying the adhesive system, and no more difference between the different treatments of dentin surface.

Systems adhesives which this is the solvent acetone are more sensitive to lack of moisture, because its components evaporate very easily and, in the absence of moisture, without provide adequate diffusion of monomers or even promotes dentin dehydration.[20,21] When placed in the wet demineralized dentin, acetone is mixed with the waste water causing the diffusion of resin monomers in the space previously occupied by water.[22] But in this study, Solobond M, that contains acetone as solvent, presented similar performance in wet and dry dentin.

The groups that remained wet dentin showed values of strength of adhesion higher statistically significant for groups with dry dentin, since the adhesive system that user acetone or alcohol, because when these solvents evaporate if the collapse of collagen fibers is prevented by stiffening those who remain in the state of expansion.[22] Furthermore, water-based adhesives can provide reexpansion of collapsed collagen fibers by drying the surface.[23] Meanwhile these adhesives are more sensitive when the residual moisture of the dentin is more constrained because the sum of the residual water from the surface with that present in its composition.[24]

The regional differences among dentin surfaces in the same preparation cause nonuniform resin bonding because it is not uncommon to have over-wet and over-dry regions on the same surface.[25]

While it is known that immediate bond strength of total-etch adhesive systems are high on a moist surface and that these values reduce overtime, there is little information on the effect of residual water in dentin on the stability of bonding.

Moisture is necessary for good bonding to dentin, but residual water may prevent complete monomer infiltration to the bottom of the demineralized zone, and cause phase separation in some adhesive systems that compromises ideal adhesive infiltration and polymerization.[26,27]

CONCLUSION

Within the limitations of this study, it could be concluded that:

- The adhesive system did not influence in the bond strength.
- The groups with wet dentin showed higher values of bond strength than groups with dry dentin.
- It is not possible to relate the difference in the bond strength with the type of solvent in the adhesives systems evaluated.

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