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MICROTENSILE BOND STRENGTH OF A SOLVENT FREE SELF-ETCH ADHESIVE SYSTEM TO WET AND DRY DENTIN

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ABSTRACT

Aim: This research was designed to evaluate the effect of dentin wetness and solvents containing of one step self-etch adhesives on the microtensile bond strength (mTBS) of dentin at different storage times. ***Materials and method:*** Occlusal dentin of 54 extracted human molars was exposed. Then, each adhesive agent was applied according to manufacturer instructions to wet and dry dentin surface, then composite resin was incrementally built up. Bond strengths to dentin were determined using mTBS test after water storage for 24 hours, one month, and six months. ***Results:*** solvent containing self-etch adhesives provided higher initial mTBS than solvent free self-etch adhesive system. Dentin dryness increased the mTBS with solvent containing adhesives, while decrease the mTBS with solvent free adhesive. No statistical significance difference was found between different storage times in mTBS for solvent free adhesive, while a statistical significance difference was found between different storage times in mTBS for solvent containing adhesives. ***Conclusion:*** Solvent free in self-etch adhesive has adverse effect on dentin bond strength in short term, but enhances the durability of dentin bond strength.

INTRODUCTION

Patient demand for esthetic restorations has generated interest in the advancement of adhesive dentistry. The achievement of high strength, durable bonds between tooth structure and restorative materials has been a long-term goal of the dental profession. Enamel and dentin bonding has progressed from multi-step systems to simplification of the application procedure in order to reduce technique-sensitivity and working time. The most simplified adhesive system is the all-in-one type and this includes all components in one bottle [(1)].

Self-etch adhesives contain high concentration of solvents which must be eliminated after complete their function because the residual solvent leads to deterioration of the adhesive interface between tooth structure and composite resin by interfering with resin polymerization [(2)]. Complete solvent elimination by air drying difficult to achieve, consequently, some residual solvent remains trapped in the adhesive [(3)].

The use of solvent-free adhesives may enhance the tooth adhesion free from the residual solvent. Because these adhesives are hydrophobic and dense, they have less water sorption and solubility than solvated resin blends [(4)].

Bond strength testing remains one of the key aspects used to screen new products and study the influence of experimental variables. Adhesive performance on enamel and dentin may be quantified using several methodologically distinct approaches, roughly divided into macro or micro setups, depending upon the size of the bonded area. The macrobond strength, with a bonded area larger than 3 mm2, can be measured in shear or tensile mode [(5)].

To improve stress distribution and the range of bond strength values, shear and tensile tests were

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almost completely replaced by the microtensile bond strength (mTBS) and microshear bond strength test. A better stress distribution can be accomplished in smaller specimens, since the number of voids and stress-raising factors is lower than the ones that possibly occur in larger areas, such those used for shear or tensile bond strength tests [6].

MATERIALS AND METHODS

1-Selection and preparation of teeth:

A total 54 freshly extracted human molars were selected. Each tooth was embedded vertically in the specially fabricated cylindrical plastic mold to the level of the cemento-enamel junction of the tooth. Grinding machine was used to wet grind 2mm from the occlusal surface to expose the dentin by using a grit carborundum disc. The dentin surface was further abraded using a #600 grit wet silicon carbide abrasive paper for 60 seconds under running water to produce a polished surface.

2. Grouping of specimens:

The teeth were divided into 3 main groups (18 teeth each) according to the type of one step self-etch adhesive system; solvent free adhesive {Bond-1SF (SF)}, ethanol-water based adhesive {Single Bond Universal (SB)} and acetone-water based adhesive {G-aenial Bond (GB)}. Each group was subdivided into 2 equal subgroups (9 teeth each) according to the condition of dentin surface, wet and dry dentin surface. Then each adhesive agent was applied according to manufacturer instructions to wet and dry dentin surface, then composite resin was incrementally built up. Each subgroup was further divided into 3 divisions of (3 teeth each) according to the storage times; one day, one month and six months. The specimens were sectioned by using IsoMet 4000 microsaw device to produce multiple beam-shaped sticks with dimensions of 1x1x8mm. Then, the mTBS was assessed by using a universal testing machine.

RESULTS

SB showed the statistically significantly highest mean mTBS, followed by GB, while the SF showed the statistically significantly lowest mean mTBS on wet and dry conditions regardless the storage times.

With solvent containing adhesives, the mTBS of dry-dentin groups was significantly greater than that of wet-dentin, while with SF dentin wetness significantly increases the mTBS.

No statistically significance difference was found between different storage times in mTBS for SF while a statistical significance difference was found between different storage times in mTBS for solvent containing adhesives. At six months storage time, no statistical significance difference was found between different adhesives agents regardless the dentin condition (figure 1).

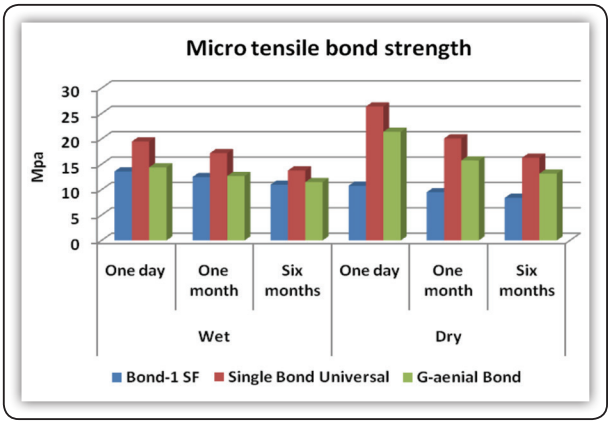

FIG (1) Bar chart representing micro-tensile bond strength of the adhesive agents with dentin condition and storage times.

DISCUSSION

One of the problems faced in adhesive dentistry is resin-dentin bond degradation by water over a period of time. Bonding to enamel remains the simplest and most reliable of all adhesive procedures, while bonding to the dentin is difficult mainly due to the contents of the dentin [7].

The results of the present study revealed that, solvent containing self-etch adhesives provide higher initial mTBS than solvent free self-etch adhesive system. This can be explained by that, the presence of water as solvent in the composition of self-etch systems is necessary to ionize the acidic monomers and trigger the demineralization process. The other co-solvents like ethanol are added to form an azeotropic mixture with water and thus accelerate the water remove by means of air syringe drying, and also promote the diffusion of monomers into the dentin [8]. On the other hand, the solvent free adhesive system failed to penetrate in-between dentin structures and to form sufficient hybrid layer, which affected the bond quality of resin composite to dentin [9].

Moreover, the solvent free adhesive system not has solvents in its composition so that, the resin tags in solvent free adhesive system seem to be less numerous and shorter than solvent containing adhesives, which might be attributed to less chance of the adhesive to penetrate into the demineralized dentin [10]. This is confirmed with the results obtained by previous study [9], which concluded that, elimination of the solvent from self-etch adhesive systems may decrease or hinder the infiltration of adhesive components into dentin, which lead to debility of hybrid zone formation and decrease of the bond strength to the dentin.

Regarding the dentin hydration, the current results showed significant increase in the mTBS of SF with wet dentin, this may be related to the SF does not contain water and in the dry dentin the adhesive could not remove the smear layer effectively. There would be poor penetration of bonding resin into the underlying dentin, which eventually leads to poor hybrid layer formation [11]. Moreover, the water is required to dissociate these monomers to release the hydronium ions (H3O+) which bring about demineralization [1]. The result of this study is in agreement with the results obtained by another study [12], which suggested that prolonged air-drying of the dentin surface removes water and decreases the bond strengths of SF.

While with the solvent containing adhesives, mTBS to dry dentin was significantly greater than to wet dentin, which could be attributed to, the moisture on the wet dentin surface may dilute the adhesives, thus decreasing the etching effect of the adhesives, which might decrease the potential for hybridization and finally lead failure of the resin composite bond strength [13]. Moreover, excess water could decrease the bond strength due to competition with monomers for infiltration into the substrate. Water might reduce the degree of conversion and interfere with polymerization. As a result, unpolymerized acidic monomers could continue to etch the dentin, which will lead decreasing on the bond strength [14]. This is in agreement with the results obtained by previous study [15]; they found that the adhesives applied to dry dentin showed higher bond strength than blot dry dentin.

According to the storage, the mTBS of all adhesives agents decreased with time. This may be related to that, the ability of simplified resin bonding systems to absorb water plays an important role in hydrolytic degradation of resin–dentin bonds after long-term water storage [16]. Also, the water can infiltrate and decrease the mechanical properties of the polymer matrix, by swelling and reducing the frictional forces between the polymer chains, a process known as 'plasticization'[17].

Whatever, the SF showed no significant decrease in the mean bond strength after aging. This may be due to the unique composition of this adhesive, which contains neither water nor organic solvents in the ingredients in order to eliminate technical issues in terms of evaporation of solvents and concerns for the durability of resin-dentin bond [18]. Moreover, the non-solvated adhesives are less hydrophilic and exhibited lower water sorption, solubility and higher degree of conversion when compared to solvated one [19].

With solvent containing adhesive agents, at six months, the dentin bond strength has large drop. This could be attributed to the presence of water, a high concentration of hydrophilic domains and residual solvents affect the polymerization reaction, leading to suboptimal degree of conversion and reduced bond longevity as a result of the elution of unreacted monomers. The final consequence of this process is the formation of a porous structure and permeable membrane. Therefore, simplified adhesives are characterized by increased water sorption, which promotes polymer swelling and other water-mediated degradation phenomena [20].

The air drying is not able to accomplish significant solvent evaporation in the solvent containing adhesives [21]. As both acetone and ethanol evaporate faster than water because they have higher vapor pressures. Their evaporation increases the concentration of monomers in the adhesives, which lowers the vapor pressure of the remaining residual solvents, making it impossible to evaporate all solvents during air-drying stage [22]. The residual water and solvents is responsible for producing localized areas of incomplete monomer polymerization which generating porosities within the bonded interfaces, in turn, may permit inward diffusion of water molecules during storage. Moreover, water may have diffused freely through the nanoporosities that were left after evaporation of solvents/unreacted monomers [19]. This is confirmed by the results of another previous study [18], which found that, the mTBS of solvent containing one-step self-etch decreased significantly after aging for six months, while in solvent free self-etch adhesive there was no significant decrease in the mTBS after aging for six months.

CONCLUSIONS

1. Solvent free in self-etch adhesive has adverse effect on dentin bond strength in short term, but enhances the durability of dentin bond strength.
2. The type of solvent may has an obvious effect on the dentin bond strength. Ethanol-water based one step self-etch adhesives showed better bonding to dentin than acetone-water based self-etch adhesives.
3. Dentin wetness increases the bond strength with solvent free self-etch adhesives, while decrease the dentin bond strength with solvent containing self-etch adhesives.
4. The storage has adverse effect on the dentin bond strength with solvent containing adhesives, while has no effect on the dentin bond strength with solvent free adhesive.

RECOMMENDATIONS

1. The clinician should have a clear and thorough understanding of the chemical composition and the mechanism of various dentin bonding agents.
2. Further studies should be done to evaluate the durability of solvent free one step self-etch adhesives more than 6 months of storage time.
3. Further in vivo studies are suggested.

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