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INFLUENCE OF ADHESIVE THICKNESS ON TENSILE BOND STRENGTH TO DENTIN

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ABSTRACT

Aim: The purpose of this study was to evaluate the effect of single and multiple consecutive applications of all-in-one self-etch adhesive on the tensile bond strength (TBS) to dentin. **Materials and Methods:** Tetric N-bond self-etch all-in-one adhesive was used in the study. Thirty extracted human mandibular molars mounted in self-cure acrylic resin and with the occlusal enamel removed were divided into three groups based on the number of applications of adhesive. Group 1: Single layer of adhesive; Group 2: Two layers of adhesive; Group 3: Four consecutive layers of adhesive. Resin composite build-ups were made, and TBS was estimated using a universal testing machine. **Results:** There was an increase in TBS when two layers of adhesive were applied compared to single and four layer applications ($P < 0.001$). **Conclusion:** Bond strength with two consecutive applications of all-in-one self-etch adhesive was significantly higher than with a single application, but application of further coatings caused a decrease in bond strength.

INTRODUCTION

Bonding to enamel is considered a durable and predictable clinical procedure while bonding to dentin has been inconsistent.[1] The dynamic nature, structure and chemistry of this anisotropic biologic composite affects the bonding mechanism.[2] To overcome these problems, dental adhesive systems have evolved through several generations depending on how the three cardinal steps of etching, priming, and bonding to tooth substrates are accomplished. In recent times, introduced all-in-one adhesive further combined these three bonding procedures into a single step. However, several authors have reported that all-in-one self-etch adhesive systems did not improve bonding effectiveness to dentin in spite of their purported reduction in technique-sensitivity.[3] As these products create very thin coatings, they may be oxygen inhibited and hence poorly polymerized. To offset these limitations, altered bonding protocols like multiple applications of adhesive that increase resin-dentin bond quality were suggested.[4,5] The purpose of this study was to determine the effect of single and multiple consecutive coatings of all-in-one self-etch adhesive on dentin bond strength.

MATERIALS AND METHODS

Thirty freshly extracted caries free, unrestored human mandibular molars stored in distilled water were used for the study. The teeth were ultrasonically cleaned and mounted in self-cure acrylic resin. The occlusal surface was ground using a water cooled diamond disc mounted on a slow speed micromotor handpiece resulting in exposure of flat dentin surface, with enamel at periphery. The exposed dentin surface on the occlusal surface was hand polished to 600 grit on a series of silicon carbide papers under running water for 30 s in order to create a standardized smear layer.[6] The specimens were randomly divided into three groups of 10 teeth each.

Group 1

Single layer of Tetric N-bond self-etch adhesive (Ivoclar Vivadent, Schaan, Liechtenstein) was applied to the exposed dentin surface using a fully saturated applicator tip of adhesive for 30 s and then gently air-dried for 3 s until there is no longer any movement of the material and light-cured for 10 s using Blue Phase C8 LED unit at a light intensity of 800 mW/cm2.

Group 2

Two layers of adhesive were applied in the same manner as described in Group 1. Light-curing was done after the application of the each layer of adhesive.

Group 3

In this group, four layers of adhesive were applied. The adhesive application and solvent evaporation steps were done repeatedly, with light-curing done after the application of each layer.

At the completion of the bonding procedure a hollow polyvinyl cylinder with the inner diameter of 6 mm and height of 4 mm was placed on the treated dentin surface almost at the center of the specimen and Tetric N Ceram composite resin was condensed to 2 mm thickness and light-cured for 20 s. Another 2 mm thickness of composite resin was placed over the first placed composite increment. A 26-gauge ligature wire was twisted at one end, and a loop formed at other end. Twisted end was placed inside the 2 mm of uncured composite resin. The composite resin was then light-cured for 20 s. Following complete curing polyvinyl cylinder molds were cut and removed, leaving the 4 mm of resin with ligature wire bonded to dentin. All the specimens were immersed in water for 24 h. While the twisted end of the ligature wire is embedded in bonded specimen, the loop end is then engaged to the hook of universal testing machine (Shimadzu, Japan) and pulled for measurement of TBS at a cross head speed of 1 mm/min.

RESULTS

Table 1: Comparison of mean TBS values between three groups

Group	n	Mean	SD	P	Post hoc test
1	10	6.94	0.71	<0.001	2>1, 3
2	10	11.39	0.71		
3	10	7.20	0.52		

These values were subjected to statistical analysis ANOVA with *post hoc* Tukey HSD test. P value set for the significance level of 0.05. There was a significant difference in the mean tensile strength among the study groups ($P < 0.001$). Post hoc analysis was performed to evaluate the significant intergroup comparisons. Post hoc analysis showed that the Group 2 has got the highest mean tensile strength than Group 3 and Group 1.

By the above results, we can infer that there was an increase in bond strength as the number of coatings increase from one to two, followed by a decrease in bond strength with successive coatings.

DISCUSSION

Bonding to dentin represents a challenge to clinical scientists, as the substrate is an intrinsically wet organic tissue, penetrated by tubular structures that communicate with the pulp. Most of the today's adhesives are often regarded as technique-sensitive with the smallest error in the clinical application procedure being penalized either by rapid debonding or early marginal degradation.[7] As a consequence, the demand for simpler, more user-friendly

and less technique-sensitive adhesives have led to the introduction of self-etch adhesives. The present study was conducted to evaluate the effect of multiple consecutive coatings of all-in-one self-etch adhesive on dentin bond strength.

Tetric N-bond all-in-one self-etch adhesive was used in this study. Composition of which includes bis-acrylamide, water, bis-methacryl amide dihydrogen phosphate (MDP), Amino acid acrylamide, hydroxyl alkyl methacrylamide, highly dispersed silicon dioxide, catalysts and stabilizers. The rationale behind selection of Tetric N-bond is that it contains hydrolytically stable methacrylamide monomers instead of the common reactive dilutent 2-hydroxyethyl methacrylate (HEMA) which is particularly instable in aqueous acid due to the formation of hydrolysis-prone associates. In recent times, Salz and Bock [8] compared the adhesive properties and storage ability of methacrylamide monomers to methacrylate-based adhesive formulations and reported that HEMA-free formulations performed more reliably, with the fully acrylamide-based adhesive consistently giving the highest dentin bond strength values. In the present study, the exposed dentin surface in Group 1 was treated with adhesive according to manufacturer's instructions which may result in a layer that is too thin for successful photoploymerization. In Group 2 and Group 3, multiple consecutive coats were applied with light-curing after each coat.

The method of light-curing after application of each coat was selected, as for simplified adhesive systems, which possess solvents in their composition, the improved adhesive thickness makes it more difficult to volatilize the solvent before light-curing, and this results in lower bonding

values.[9] Moreover, the effect of repeated light-curing to the first coat of bonding resin may be able to increase the conversion of the adhesive resin, enhancing bond strength.

In the current study, the highest mean TBS was obtained with two consecutive applications of adhesive. The probable reason for the lower TBS for group with single coat application is single coat results in a layer that is too thin for photopolymerization which is been inhibited by oxygen.[10] Pashley et al.[2] observed that an additional application of bonding agent could seal the nonpolymerized oxygen inhibition layer, thus enabling it to be adequately polymerized.

Furthermore, the HEMA-free self-etch adhesive system used in the present study contains MDP monomer which is speculated to have chemical interaction with hydroxyapatite crystals forming stable calcium-phosphate and calcium-carboxylate salts, respectively, along with only a limited surface-decalcification effect (“Adhesion-Decalcification concept”).This additional chemical interaction is also thought to particularly improve bond durability.[11] In accordance with the present study, Mandava et al.[12] demonstrated increase in bond strength for two consecutive applications of adhesive followed by decrease in bond strength with successive coatings.

Ausiello et al.[13] who analyzed the effect of adhesive layer properties on stress distribution in composite restorations with three-dimensional finite element analysis, showed that the greater the adhesive thickness, the higher the elastic release effect. In the present study, there was a decrease in bond strength when more than two multiple consecutive coatings were applied. This might be due to increase in the thickness of the adhesive layer, which acts as a weak interface and resulted in total cohesive failure.[14] D'Arcangelo et al.[9] stated that the ideal adhesive thickness is certainly variable and depends on the adhesive system used. Clinicians should consider the intrinsic properties of each bonding system when using a multilayering technique.

CONCLUSION

The present study shows that bond strength with two consecutive applications of all-in-one self-etch adhesive was significantly higher than with a single application, but application of further coatings caused a decrease in bond strength. The results of the present study confirm how important bonding technique is to producing optimal resin-dentin bonds. The short application time recommended by the manufacturer may not be sufficient to allow the chemical bonding mechanism to take place for self-etch adhesives. Simple changes in bonding technique, such as applying two layers of all-in-one adhesives can lead to the larger increase in initial bond strength.

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