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Effect of Different Pretreatment Methods on Dentin Bond Strength of a One-step Self-etch Adhesive

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Abstract

Aim: The aim of this *in vitro* study was to evaluate the shear bond strength of a one-step self-etch adhesive to dentin pretreated with phosphoric acid, air abrasion, or laser.

Methods and Materials: Fifty-six extracted non-carious human mandibular molars were mounted and the occlusal surfaces ground with a mechanical grinder to obtain flat occlusal dentin surfaces. The teeth were randomly divided into four groups of 14 teeth according to the different dentin surface pretreatment methods: Group I- Acid, Group II- Laser, Group III- Air abrasion, Group IV (Control)- No surface treatment. After applying a one-step self-etch adhesive system, Futura Bond NR, cylinders of Z250 composite resin were bonded to the dentin surfaces by transparent gelatin capsules (2.5 mm diameter; 3 mm high) and then polymerized. All specimens were stored in distilled water at 37ºC for 24 hours. Shear bond testing was carried out using an Universal testing machine with a crosshead speed of 0.5 mm/sec. Data were analyzed using the Kruskal Wallis and Mann-Whitney tests at a significance level of 0.05.

Results: The bond strength of air abrasion (Group III) and the control group (Group IV) were statistically higher than both the acid (Group I) and laser (Group II) pretreatments ($p<0.05$). No statistically significant differences were found in shear bond strength between surfaces treated with air abrasion and the control group ($p>0.05$). Surfaces pretreated with laser (Group II) resulted in the lowest bond strength which was not statistically different from those pretreated with acid (Group I) ($p>0.05$).

Conclusion: Surfaces pretreated with acid and laser adversely affected the bond strength of a one-step self-etch adhesive, Futura Bond NR, while pretreatment with air abrasion had no effect on bond strength.

Clinical Significance: The pretreatment of dentin surfaces prior to self-etch adhesive seems to be unnecessary and defeats the original purpose of these systems.

Keywords: Acid etching, air abrasion, laser, self-etch adhesives

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Introduction

Recently, one-step self-etch adhesives that combine the etching, priming, and bonding procedures into one solution have been introduced to reduce steps required for bonding. Because of this feature they have gained a high degree of acceptance in the dental profession. One-step self-etch adhesives are composed of aqueous mixtures of acidic functional monomers, generally phosphoric acid esters, and, therefore, do not require separate acid-etching. Simultaneous etching and priming facilitates penetration of the adhesive resin monomer into etched dentin and decreases the risk of collapse or degradation of dentin collagen.[1,2] Strong self-etch adhesives dissolve and remove the smear layer by dispersion within the adhesive layer. Mild self-etch adhesives cannot dissolve the smear layer and it is incorporated into the hybrid layer.[3,4] So the ability of self-etch adhesives to demineralize dentin might depend on the pH. Because self-etch adhesives may not always properly and uniformly etch smear layers, the efficiency of these simplified adhesive systems is still controversial. Additional dentin surface treatments such as acid etching, air abrasion, or laser etching may lead to improved bonding.

Acid etching is routinely used to etch and roughen dental surfaces. Air abrasion is also promoted as an alternative conditioning method of tooth surfaces.[5] This system uses air pressure with alumina powders to abrade dental tissues and produce a rough irregular surface with large surface areas.[6,7] More recently, laser technology has gained popularity and many applications in dentistry have been proposed such as caries removal, cavity preparation, and desensitization.[8-10] Lasers have also been suggested as a pretreatment method to roughen tooth surfaces.[7-11] Although there are many types of lasers, the Er: YAG laser has proved to be the most promising system.[12] This laser, with a 2.94 mm wavelength emission, can effectively remove dental hard tissue due to its high absorbability in both water and hydroxyapatite.[13] Moreover, the Er: YAG laser does not cause injury to the pulp or severe thermal effects to the remaining tooth structure and may be useful in preparing dental hard tissues for adhesion.[14]

A few studies have compared the bond strength of self-etch adhesive systems to those used in conjunction with acid etching.[15-17] The aim of this

Table 1. The adhesive system used in the study.

Adhesive Sysytem	Composition	Application Mode
Futura Bond NR Batch # 641657 Voco,Cuxhaven, Germany	Bis-GMA, HEMA, BHT, ethanol, organic acids, fluorides	Apply a layer of adhesive, massage into the tooth substance for 20 seconds. Dry the adhesive layer with the air jet for at least 5 seconds. Polymerize for 10 seconds.
Abbreviations: Bis-GMA: bis-phenol A diglycidylmethacrylate; HEMA: 2- hydroyethyl-methacrylate; BHT: butylated hydroxy toluene		

study was to compare the shear bond strength of a self-etch adhesive to dentin pretreated with acid, air abrasion, or laser.

Methods and Materials

Fifty-six extracted non-carious human mandibular molars stored in 0.1% thymol solution at 4ºC for no longer than one month were used for this study. The teeth were mounted in self-cure acrylic resin. The occlusal surface of each tooth was ground flat on a water-cooled mechanical grinder (Ecomet, Buehler, IL, USA) using 120-grit silicon carbide abrasive paper to expose occlusal dentin. The dentin was polished with 320- and 600 grit silicon carbide paper on the same device. The dentin surface was examined in a dissecting microscope at x50 magnification to ensure no enamel was left on the surface. The teeth were randomly assigned to one of four groups (n=14) according to dentin surface pretreatment method:

- **Group I: Acid.** Dentin surfaces were treated with 34.5% phosphoric acid (Vococid, Voco, Cuxhaven, Germany) for 15 seconds and rinsed for 10 seconds.
- **Group II: Laser.** Dentin surfaces were irradiated with an Er: YAG laser at 140mj 4Hz for 10 seconds. The laser beam was delivered in non-contact mode, and the spot size was about 1 mm in diameter.
- **Group III: Air Abrasion.** Dentin surfaces were treated with an air abrasion unit (PrepStar, Danville Instruments, Danville, CA, USA) with 27-micrometer aluminum oxide particles at 120psi pressure for 5 seconds. During the application of air abrasion, the nozzle distance was stable at 2 mm from sample surface. After air abrasion, the teeth were throughly rinsed with a vigorous air/water spray for 1 minute to remove residual aliminum particles from the surface.
- **Group IV: No Treatment.** The dentin surface was left untreated and used as control.

One-step self-etch adhesive system, Futura Bond NR (Voco, Cuxhaven, Germany), was used according to the manufacturer's recommendations (Table 1).

The adhesive system was applied to dentin for 20 seconds, dried with an air jet for 5 seconds, and cured for 10 seconds with Hilux curing light (Benlioglu, Ankara, Turkey) with a power output maintained at 400mW/cm^2. The light output of the curing unit was monitored with a light meter (Curing Radiometer Model 100, Demetron Corp, Danbury, CT, USA). Following application of the adhesives, a transparent gelatin capsule (2.5 mm in diameter and 3 mm in length) was seated securely against the flattened dentin surface. A hybrid composite resin, Z250 composite resin (3M, St. Paul, MN, USA), was incrementally placed into the capsule and polymerized for 40 seconds. All specimens were stored in distilled water at 37ºC for 24 hours. Specimens were tested in shear mode using a shear knife-edge blade in an Universal testing machine (Llyod, UK) with a crosshead speed of 0.5 mm/sec. The shear bond strength in MPa were calculated from the peak load at failure divided by the specimen bonding surface area. The mean bond strengths were compared using Kruskal-Wallis and Mann-Whitney tests at a significance level of 0.05.

Results

The mean shear bond strength and standard deviations for all groups are presented in Table 2.

The bond strength of air abrasion (Group III) and the control group (Group IV) were statistically higher than other groups ($p<0.05$). No statistically

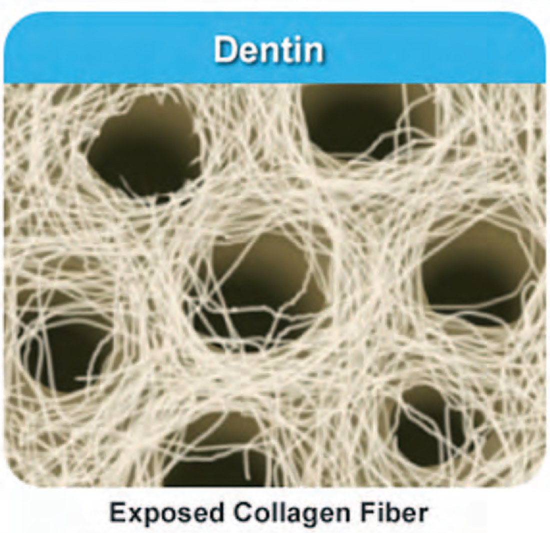
Table 2. Mean shear bond strength values (MPa± SD).

Surface Pretreatment Methods	Mean Shear Bond Strength Values (MPa± SD)
Group I- Acid	9.84 ± 5.71[a]
Group II- Laser	8.06 ± 5.62[a]
Group III- Air-abrasion	14.09 ± 5.94[b]
Group IV- Control (No treatment)	14.44 ± 6.23[b]
Note: Within the same row identical letters indicate no significant differences (p>0.05).	

significant differences were found in shear bond strength between the air abrasion and control group (p>0.05). Group II (Laser) resulted in the lowest bond strength and was not statistically different from Group I (Acid) (p>0.05).

Discussion

Self-etch adhesives contain acidic functional monomers that causes the surface to be demineralized, which results in dissolving the smear layer and exposing collagen fiber.[18] The self-etch adhesive used in the present study was Futura Bond NR with a pH of 1.4 and is categorized as a 'mild' self-etch adhesive. The pH value of the primer increases after contact with the dentin smear layer by buffering action, so the effect of the primer might be less prominent. This leads one to question whether, with the use of additional dentin pretreatment methods,



a higher bond strength will be obtained. In the current study the reduced bond strength values when an acid etching pretreatment was performed before application of a self-etch adhesive was demonstrated. In a recent study,[15] using Clearfil SE Bond with additional acid etching, lower bond strength to sound dentin was reported. One explanation for the decrease in bond strength might be excessive etching of dentin, thereby, limiting penetration ability of monomer up to the same depth of demineralized dentin through the presence of extended and collapsed collagen fiber. In other words deeper demineralization may prevent proper resin infiltration, hence, compromising the bond strength. Van Landuyt et al.[16] evaluated the microtensile bond strength of a two-step self-etch adhesive to enamel/dentin with or without prior etching with phosphoric acid. They found phosphoric acid etching prior to Clearfil SE Bond application on dentin significantly decreased the bond strength and attributed this result to the increased transdentinal permeability of dentin after acid etching. Several studies have also confirmed the bond strength of self-etch adhesive to acid etched dentin was reduced because of the incomplete infiltration of the demineralized collagen network by the bonding resin.[19-21]

Laser irradiation cause fungiform formations, opened dentin tubules without smear layer production.[22] Therefore, laser etching may be a feasible method to improve the adhesion of a restorative material to the tooth structure. Although dentin with a high water content has a strong affinity to Er: YAG laser irradiation, the effects of Er: YAG laser on collagen network has not been fully understood. The results of the present study revealed that pretreatment of dentin surfaces with Er: YAG laser resulted in decreased bond strength. This finding is consistent with Ceballos et al.[23] who also found Er-YAG laser created a laser-modified layer that adversely affects adhesion to dentin. Previous studies also reported self-etch adhesives bond significantly less effectively to lased dentin.[24-27] According to these studies, the major reason for the decrease in bond strength is the subsurface damage, fissuring, cracking, and a fusion of collagen fibrilles initiated by the Er: YAG ablation. Penetration of adhesive monomers to the altered or fused collagen would probably hamper the adhesive bond strength.

In the present study air abrasion pretreatment did not affect the bond strength to dentin. This result agrees with those of Franca et al.[28] who reported self-etch adhesives showed similar bond strength regardless of aluminum oxide air abrasion treatment. Chaves et al.[29] evaluated the bond strength of two self-etching adhesive systems and one one-bottle system applied on dentin surfaces after different smear layer treatments; sandblasting with 50*μ* Al_2O_3 for 10 seconds, etching with 36% phosphoric acid for 15 seconds, or conditioning with 0.5 M EDTA for 2 minutes, and no treatment. Chaves[29] found different smear layer treatments prior to bonding did not affect tensile bond strength. In another study[30] evaluating the effectiveness of previous dental surface treatments on the bond strength of two self-etching adhesives, the highest mean bond strength to enamel was found with previous phosphoric acid etching and to dentin when EDTA was previously applied.

Since great variability exists in the composition of adhesives, these results cannot be generalized. However, under the limitations of this *in vitro* study, the need for pretreatment of dentin prior to application of self-etch adhesives is somewhat controversial and defeats the original purpose of these systems.

Conclusion

While the pretreatment of dentin surfaces with acid or laser prior to application of a one-step self-etch adhesive reduced the bond strength, air abrasion pretreatment had no effect on bond strength.

Clinical Significance

The pretreatment of dentin surfaces prior to self-etch adhesive seems to be unnecessary and defeats the original purpose of these systems.

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