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Effect of a Desensitizing Agent on Microshear Bond Strength of Two Bonding Systems

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Abstract

Background and Aim: Postoperative tooth hypersensitivity after restorative procedures is a common finding. Considering the obstruction of dentinal tubules following the use of dentin desensitizers, there are some concerns about the effects of desensitizers on the bond strength of bonding systems. This study aimed to assess the effect of a desensitizer on microshear bond strength (μSBS) of two bonding systems.

Materials and Methods: In this in vitro study, 20 sound human molars were mesiodistally sectioned into halves, and the roots were cut at the cementoenamel junction. The samples (n=40) were then randomly divided into four groups (n=10): (I) Adper™ Single Bond 2, (II) Desensibilize desensitizing agent+ Adper™ Single Bond 2, (III) Single Bond Universal, and (IV) Desensibilize desensitizing agent + Single Bond Universal. Adhesives and desensitizing agents were applied according to the manufacturers' instructions. Filtek Z250 composite cylinders were fabricated and bonded to dentin surfaces. The μSBS of each sample was then measured. Data were analyzed by one-way ANOVA and a post-hoc test ($P<0.05$).

Results: A reduction in μSBS was found following the application of desensitizing agent in combination with Adper™ Single Bond 2 ($P<0.05$). The μSBS increased when the desensitizing agent was applied in combination with Single Bond Universal. However, this difference was not significant ($P>0.05$).

Conclusion: Desensibilize desensitizing agent affected the dentinal tubule obstruction and decreased the μSBS when used with Adper™ Single Bond 2 total-etch system, while the μSBS increased when it was used with Single Bond Universal adhesive.

Keywords: Dentin Desensitizing Agents; Shear Strength; Dentin-Bonding Agents

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Introduction

Dentin hypersensitivity is a common finding that occurs due to exposure of dentinal tubules to the oral cavity. It affects around 1% to 35% of the population [1]. Dentin hypersensitivity is characterized by a short and sharp pain in response to thermal, mechanical, and osmotic stimuli [1,2]. Some other factors such as pH alterations can also cause dentin hypersensitivity [3].

Due to dentin's dynamic and moist nature, bonding to dentin is not as durable as bonding to enamel. Several mechanisms are involved in bonding of adhesives to tooth structure such as physical absorption, micromechanical interlocking, chemical and ionic bonds, and acid-base reactions. The weak bond between the restorative material and dentin causes problems such as secondary caries development, postoperative tooth hypersensitivity, discoloration, and microleakage [4-6].

To achieve optimal bond strength and an airtight seal, resin should penetrate deep into peri-tubular and inter-tubular dentin to form resin tags and a uniform hybrid layer [7]. Achieving a strong chemical bond between the tooth structure and restorative material with the help of an adhesive is difficult due to the complex composition of some substrates like dentin, surface contamination, and presence of water [2]. Some desensitizing agents with a mechanism of action of obstruction of dentinal tubules may interfere with successful bonding [8,9]. Several studies have evaluated the bond strength of different dentin bonding agents following the application of desensitizers [8].

Considering the increasing use of universal adhesives, which are the newest generation of adhesives, this study aimed to evaluate the effect of a desensitizing agent on microshear bond strength (μSBS) of a universal adhesive and a fifth-generation bonding agent.

Materials and Methods

In this in vitro experimental study, 20 sound molars with no visually evident caries, hypoplastic defects, or cracks on their buccal and lingual surfaces were evaluated. The present study was ethically approved by the Research Council, Dental Faculty of Islamic Azad University, (RES.CCL.DENT.IAU.1395.728).

The teeth were immersed in 0.5% chloramine-T solution for 7 days at room temperature for disinfection, and then stored in sterile distilled water at 4°C until the experiment.

Tooth preparation:

The collected teeth were longitudinally sectioned in a mesiodistal direction at their central groove using a CNC cutting machine (Nemophanavaran Pars, Tehran, Iran) at low speed. The roots were then separated from the crowns at the cementoenamel junction using the same cutting machine [10]. The buccal and lingual enamel were completely removed, and the tooth surface was abraded with 180-, 400-, and 600-grit silicon carbide abrasive papers under running water (60 seconds each) until dentin was exposed [11]. The samples were then randomly divided into four groups of 10 (Table 1).

Table 1. Study groups

Group 1	etchant + Adper™ Single Bond 2 + composite resin
Group 2	etchant + Desensibilize + Adper™ Single Bond 2 + composite resin
Group 3	Single Bond Universal + composite resin
Group 4	Desensibilize+ Single Bond Universal + composite resin

In groups 1 and 2, 37% phosphoric acid gel (Denfil, South Korea) was applied on the dentin surface for 15 seconds and completely rinsed. The tooth surface was then gently air-dried such that the dentin remained slightly moist. In group 2, after etching, desensitizer (Desensibilize; FGM, Brazil) was applied on the surface of dentin in one layer using a microbrush. Adper™ Single Bond 2 (3M ESPE, St. Paul, MN, USA) was then applied on the dentin surface of the samples in two layers for 15 seconds using a microbrush in both groups according to the manufacturer's instructions, and was then gently dried with air spray for 5 seconds. It was then light-cured using a quartz-tungsten-halogen light-curing unit (Coltolux, Germany) with a light intensity of 600 mW/cm2 [10].

In group 3, Single Bond Universal (3M ESPE, St. Paul, MN, USA) was applied on the dentin surface with a microbrush for 20 seconds according to the manufacturer's instructions, and gently air-dried for 5 seconds. It was then light-cured as mentioned before.

In group 4, Desensibilize desensitizing agent was applied on the dentin surface in one layer using a microbrush. Next, Single Bond Universal was applied on the dentin surface as described for group 3.

After applying the adhesive, composite cylinders were fabricated from Filtek Z250 composite resin (3M ESPE, St. Paul, MN, USA) using Tygon tubes measuring 0.7 mm in diameter and 1 mm in height, and light-cured using a quartz-tungsten-halogen light-curing unit (Coltolux, Germany) with a light intensity of 600 mW/cm2. After composite curing, the Tygon tubes were cut by a scalpel and removed. The samples were incubated in distilled water at 37°C for 24 hours (Dena, Tehran, Iran) for complete polymerization. The samples were then subjected to 2000 thermal cycles between 5-55°C with a dwell time of 15 seconds and a transfer time of 10 seconds [12]. The materials used in the present study and their composition are presented in Table 2.

Measuring the μSBS:

A universal testing machine (Bisco, Schaumburg, USA) was used to measure the μSBS. The samples were attached to the jig using cyanoacrylate glue. Shear loads were applied at a crosshead speed of 0.5 mm/minute until the composite cylinders were separated from the dentin surface. For each sample, data were collected, and the μSBS in megapascals (MPa) was calculated by dividing the breaking load (in Newtons) by the cross-sectional area of the composite cylinder (in square-millimeters). After the μSBS test, the samples in each group were examined under a stereomicroscope (SZ240; Olympus, Tokyo, Japan) at 40x magnification to determine the mode of failure, which was classified as follows:

Adhesive failure: Separation of composite from the tooth surface.

Cohesive failure: Separation of composite from composite, or dentin from dentin.

Mixed failure: A combination of cohesive and adhesive failures [13].

Statistical analysis:

Data were analyzed using SPSS version 20 (SPSS Inc., IL, USA) by one-way ANOVA. Pairwise comparisons were made by a post-hoc test. P<0.05 was considered statistically significant [14].

Table 2. Materials used in this study

Material	Material type	Manufacturer	Constituents
Etchant	37% phosphoric acid gel	DenFil/S. Korea	37% phosphoric acid
Adhesive	Adper™ Single Bond 2	3M ESPE, St. Paul, MN, USA	Bis-GMA, HEMA, dimethacrylates, polyalkenoic acid copolymer, 10wt% silica fillers (5 nm diameter), photo-initiator, ethanol, water
Adhesive	Single Bond Universal	3M ESPE, St. Paul, MN, USA	10-MDP monomer, dimethacrylate resins, HEMA, polyalkenoic acid copolymer, filler, ethanol, water, photo-initiator, silane
Microhybrid composite resin	Filtek Z250	3M ESPE, St. Paul, MN, USA	Bis-GMA, UDMA, Bis-EMA, TEGDMA, PEGDMA, zirconia and silica fillers, photo-initiator
Desensitizing agent	Desensibilize	FGM, Brazil	10% strontium chloride, 5% potassium nitrate, water, thickener, humectant

Results

Table 3 presents the µSBS of the four groups. One-way ANOVA revealed a significant difference in µSBS among the four groups ($P<0.05$). The results of pairwise comparisons demonstrated that the application of Desensibilize significantly reduced the bond strength of Adper Single Bond 2 ($P<0.05$). The application of Desensibilize resulted in an increase in the bond strength of Single Bond Universal. Nevertheless, this increase was not statistically significant ($P>0.05$). In pairwise comparisons, statistically significant differences were observed between the groups, with the exception of Single Bond Universal and Desensibilize + Single Bond Universal (P=0.297, Table 4).

Table 3. µSBS of the four groups by one-way ANOVA)

Bonding system	Mean (MPa)	Standard deviation	P value
Adper™ Single Bond 2	23.5	4.8	0.000
Desensibilize + Adper™ Single Bond 2	16.5	3.4	
Single Bond Universal	29.8	4.3	
Desensibilize + Single Bond Universal	32.9	2.9	

Table 4. Pairwise comparisons between the groups

Compared groups	P value
Adper™ Single Bond 2 Desensibilize + Adper™ Single Bond 2	0.002
Adper™ Single Bond 2 Single Bond Universal	0.006
Adper™ Single Bond 2 Desensibilize + Single Bond Universal	0.000
Desensibilize + Adper™ Single Bond 2 Single Bond Universal	0.000
Desensibilize + Adper™ Single Bond 2 Desensibilize + Single Bond Universal	0.000
Single Bond Universal Desensibilize + Single Bond Universal	0.297

The mode of failure was dominantly adhesive in all groups (Table 5). The frequency of adhesive failures was compared among the groups, which revealed no significant difference (P=0.09).

Table 5. Frequency of different modes of failure in the four groups

Group	Adhesive	Mixed	Cohesive	
			Within dentin	Within composite
Adper™ Single Bond 2	8	2	0	0
Desensibilize + Adper™ Single Bond 2	7	2	0	1
Single Bond Universal	7	3	0	0
Desensibilize+ Single Bond Universal	8	2	0	0

Discussion

In this study, the effect of a desensitizing agent on µSBS of two bonding systems was investigated. The results showed that Desensibilize significantly reduced the µSBS of Adper™ Single Bond 2 and insignificantly increased the µSBS of Single Bond Universal. This finding indicates that application of Desensibilize desensitizing agent before bonding is unlikely to have a negative impact on µSBS of Single Bond Universal. However, this was not the case for Adper™ Single Bond 2, as use of Desensibilize in this group reduced the µSBS of composite to dentin.

A desensitizer containing strontium chloride and potassium nitrate was used in the present study. Compounds containing potassium inhibit the neuronal response to painful stimuli. Potassium ions have a direct effect on irritability of the nervous system. By increasing the concentration of potassium ions near the dentinal nerve endings, nerve fibers are depolarized. A long depolarization period inactivates the fibers [15]. Materials containing strontium result in deposition of fine particles. They cause deposition of insoluble metal compounds on the dentin surface and lead to complete or partial closure of open dentinal tubules [16,17].

In the present study, statistical analysis revealed that desensitization significantly reduced the μSBS of Adper™ Single Bond 2. This result was consistent with that of Awang et al. [18] and Maeda et al. [10]. Awang et al. [18] stated that the use of a water-based desensitizer containing oxalate decreased the bond strength of Prime & Bond® NT (Dentsply, USA). They added that this reduction in bond strength was due to the reaction of oxalic acid with calcium ions in the tooth structure and formation of insoluble calcium oxalate crystals that clog the dentinal tubules [18]. Maeda et al. [10] showed that desensitization reduced the bond strength of Single Bond and Adper™ Single Bond 2. They discussed that strontium reacts with dentin calcium and produces strontium apatite, which affects dentin permeability. This reduction in dentin permeability is the most important factor responsible for incomplete resin infiltration and subsequent reduction in bond strength [10,19]. Seara et al. [20] reported that formation of strontium calcium crystals physically and/or chemically decreased monomer retention. Some studies reported that application of desensitizing agents decreased dentin permeability by 60% to 80% [21,22]. The present results showed that the desensitizing agent significantly increased the μSBS of Single Bond Universal, which was in contrast to the findings of Abi Elhassan et al. [23]. They pointed out that the use of desensitizers containing stannous fluoride and sodium fluoride had no significant influence on the bond strength of XenoIV self-etching bonding agent. Controversy in the study results may be due to the presence of 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) monomer in universal adhesives and presence of strontium in the formulation of Desensibilize, as MDP monomer can chemically bind to calcium in the tooth structure [24]. Additionally, strontium has a similar structure to calcium and can replace lost calcium in the tooth structure [25].

The present results also showed a significant difference in the mean μSBS between Adper™ Single Bond 2 and Single Bond Universal with/without desensitizer. Alkenoic acid copolymer, dimethacrylate, HEMA, ethanol, water, photo-initiator, and fillers are included in the composition of Adper™ Single Bond 2. In addition to the components of Adper™ Single Bond 2, Single Bond Universal also contains MDP monomer. Methacrylate-modified polyalkenoic acid copolymer (also known as Vitrebond™) is present in both adhesives. The MDP monomer can form ionic bonds with calcium in hydroxyapatite crystals and lead to the formation of hydraulically stable 10-MDP-Ca salts [24,26,27]. The complex combination of two MDP molecules bound together with MDP calcium salt forms a binding interface that is resistant to degradation over time [28]. Investigations on strontium show that it not only has similar physical and chemical properties to calcium, but is also involved in biological reactions like calcium [29]. Due to the high structural similarity of calcium and strontium, strontium can partially replace the lost calcium in the tooth structure [30].

Since there is no functional monomer in the composition of Adper™ Single Bond 2 that can directly bind to calcium in the tooth structure, dentin permeability determines the bond strength. After applying Desensibilize, strontium salt crystals clog the dentinal tubules and decrease their permeability. Reduced permeability leads to incomplete infiltration of adhesive, and decreases the bond strength of this adhesive to dentin [10]. Several factors influence the in vitro bond strength of dental adhesives to dentin, such as monomers, solvents, inhibitors, and activators, the proportions of which can also be different in the adhesives. Furthermore, desensitizing agents differ in composition and their mode of action. Therefore, different desensitizers may have different effects on the bond strength [14].

In view of the results, it appears that use of desensitizing agents causing dentinal tubule obstruction before the application of a total-etch bonding agent (Adper™ Single Bond 2) devoid of specific monomers that react with the tooth structure should be done with caution while using the same desensitizing agents along with a universal adhesive (Single Bond Universal) would probably be associated with less adverse effects.

Conclusion

The current results showed that the use of Desensibilize with the mechanism of action of blocking of dentin tubules decreased the μSBS of Adper™ Single Bond 2 (total-etch bonding agent) and increased the μSBS of Single Bond Universal.

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