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ORIGINAL ARTICLE

Micro-shear bond strength of resin cement to dentin after application of desensitizing toothpastes

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Abstract

Objectives. The aim of the study was to evaluate the effect of three desensitizing toothpastes on bonding of resin cements to dentin. ***Materials and methods.*** The occlusal surfaces of 72 maxillary third molars were ground to obtain flat dentin surfaces and then divided into three groups according to three desensitizing toothpastes used: Sensodyne Rapid Relief (GlaxoSmithKline, SmithKline Beecham Ltd., Slough, UK), Signal Sensitive Expert (Unilever Sanayi ve Ticaret Türk A.Ş., Ümraniye, İstanbul, Turkey) and Colgate Sensitive Pro-Relief (Colgate Palmolive, New York, NY). Following bonding of the resin cement (Clearfil™ SA Cement, Kuraray Co, Osaka, Japan) to dentin, the specimens were light cured for 40 s with a LED (Elipar S10, 3M Espe, St. Paul, MN). The strength measurements were accomplished with a micro-shear testing machine (Bisco, Schaumburg, IL) at a cross-head speed of 0.5 mm/min until the failure occurs. Failure modes were examined using a stereomicroscope and scanning electron microscope. The data were analyzed with one-way analysis of variance (ANOVA) and Tukey HSD test ($\alpha = 0.05$). ***Results and conclusion.*** ANOVA revealed that the application of desensitizing toothpastes had significant effects on bond strength of the resin cement tested to dentin ($p < 0.05$). Mixed failures were observed in all of the groups. ***Clinical significance.*** The use of a desensitizing toothpaste before cementation might alter the bond strength of adhesively luted restorations.

Key Words: *desensitizing toothpastes, micro-shear bond strength, resin cement*

Introduction

Long-term survival of adhesive porcelain restorations depends on the success of a reliable bond between porcelain, the luting agents and the dental substrates [1]. The trend toward the simplification of clinical luting procedures has led to the introduction of self-adhesive resin cements. These newer systems, that produce bonding in a simple application, eliminate the need for enamel or dentin pre-treatment, simplify the cementation technique and diminish the chances of failures of the clinical procedures [2].

Cementation is one of the reasons for dentin hypersensitivity and it may cause tooth sensitivity by the pressure created by cement before setting. This situation also occurs after tooth preparation because of the exposure of dentinal tubules [3]. Additionally, it is a common and painful oral condition that occurs when dentine is exposed to the oral environment and the smear layer covering the dentinal tubules is removed [4,5].

There are several treatment options for managing dentinal hypersensitivity that stimulate mineral deposition or occlude dentinal tubules to reduce dentinal hypersensitivity [6–8]. Desensitizing agents can be applied on prepared tooth surfaces to avoid hypersensitivity [9]. Furthermore, the toothpastes containing 8% arginine in combination with calcium carbonate, 2% potassium ion and strontium based pastes reduce hypersensitivity by occluding dentinal tubules [4].

Based on these considerations, the purpose of this study was to investigate the effect of three desensitizing toothpastes on micro-shear bond strength (μ-SBS) of resin cement to dentin. The tested null hypothesis in this study was that the toothpastes will negatively affect

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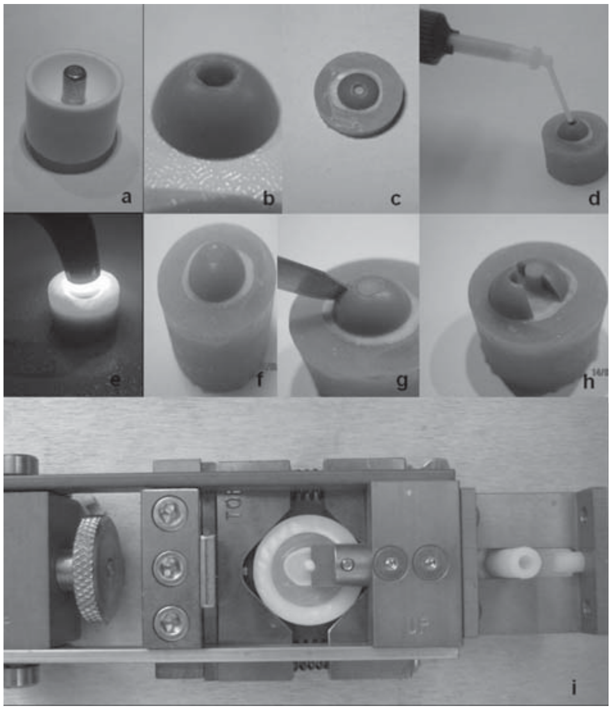

Figure 1. Schematic illustration of specimen preparation; (a) The plastic tube, (b) Fabrication of custom-made silicone mold, (c) Silicone mold placed on dentin surface, (d) Resin cement application following desensitizing paste brushing, (e) Light curing of the specimen, (f) The specimen with resin cement, (g and h) removing the mold, (i): the specimens mounted in the machine for the micro-shear test.

the bond strength of resin cements to dentin by occluding dentinal tubules.

Materials and methods

Seventy-two extracted sound human maxillary third molars extracted because of pericoronitis were collected. After soft tissue remnants were eliminated, teeth were stored in distilled water for 2 weeks. The teeth were longitudinally positioned in a polyvinylchloride cylinder with a dimension of 3 × 4 mm and embedded in an acrylic resin. In order to obtain middle dentin surfaces, enamel surfaces and 1.25 mm thickness of superficial dentin were cut with a low speed saw (IsoMet 1000, Buehler Ltd, Lake Bluff, Illinois, USA). Then each specimen was ground occlusally with silicone carbide abrasive up to paper no. 1000 (FEPA) under water cooling with a grinding machine (Struers RotoPol 11; Struers A/S, Rodovre, Denmark) to obtain a flat dentin surface.

The experimental set-up is given in Figure 1. Specimens were randomly divided into four group ($n = 18$/per group). Three different commercial toothpastes; Sensodyne Rapid Relief (GlaxoSmithKline, SmithKline Beecham Ltd., Slough, UK), Signal Sensitive Expert (Unilever Sanayi ve Ticaret Türk A.Ş., Ümraniye, İstanbul, Turkey) and Colgate Sensitive Pro-Relief (Colgate Palmolive, New York, NY) were used in the present study, due to their major ingredients, which are presented in Table I. The specimens were subjected to 2 min brushing with the three toothpastes using a rotary handpiece at 300 rpm. A custom-made silicone mold (Premium Impression Silicone, Exasoft, Detax, Ettlingen, Germany) was constructed from a plastic tube for stabilization of the resin cements on the dentin specimens before curing procedure. A self-adhesive resin cement (Clearfil™ SA Cement Kuraray Co, Osaka, Japan) was selected as a luting material. The custom-made silicone mold (with a diameter of 1 mm and a height of 3 mm) was positioned on the center of the grounded dentin surface and the cement was condensed into the mold through the mixing tip. The excess cement was removed and the specimens were then light cured for 20 s with a LED light-curing unit (Elipar S10, 3M Espe, St. Paul, MN) with an irradiance of 1200 mW/cm^2 according to the manufacturer's instructions. The output of the light was checked with a radiometer on the curing unit itself. The group that was not exposed to any toothpaste served as control. Following the curing procedure, all the samples were kept waiting in a humid condition for 24 h. Silicone molds of each specimen were cut with the tactile pressure of a lancet. The strength measurements were accomplished with a micro-shear testing machine (Bisco, Schaumburg, IL) at a crosshead speed of 0.5 mm/min until the failure occurs. Maximum stresses in Newton (N) were easily obtained from the screen of the machine. The quantitative values were converted into megapascal (MPa) by considering bonding surface area of the resin cements.

μ-SBS (MPa) = Maximum load (N)/Bonding surface area of the resin cement (mm^2) [10].

Failure modes were analyzed visually using a stereomicroscope at 40× magnification (Wild M3B, Heerbrugg, Switzerland) and classified as follows: adhesive failure between resin cement and dentin, cohesive failure within dentin or cohesive failure within resin cement and mixed type of failure. One specimen was randomly selected from each group and prepared for SEM analysis. The debonded specimens from each group were gold sputter-coated (Bal-Tec SCD 050 Sputter Coater, Bal-Tec AG, Liechtenstein) and observed with a scanning electron microscope (JSM-5500, Jeol Ltd., Tokyo, Japan).

Statistical analysis

μ-SBS data were analyzed statistically by one-factor analysis of variance (ANOVA) and Tukey's post-hoc test, with the level of significance set at $p < 0.05$. All statistical analyses were performed using a statistical software package (SPSS Inc., Chicago, IL).

Table I. Materials used in the present study.

Trade name	Components	Lot no	Manufacturer
Sensodyne Rapid Relief	Aqua, Sorbitol, Hydrated Silica, Glycerin, Strontium Acetate hemihydrate (8 wt%), Sodium Methyl Cocoyl Taurate, Xanthan Gum, Titanium Dioxide, Aroma, Sodium Saccharin, Sodium Fluoride, Sodium Propylparaben, Sodium Methylparaben, Limonene. contains Sodium Fluoride 0.23% w/w (1040 ppm fluoride)	351FP2	GlaxoSmithKline Consumer Healthcare, Weybridge, Surrey, UK
Signal Sensitive Expert	Aqua, Sorbitol, Hydrated Silica, Hydroxyapatite, Potassium citrate, Zinc Citrate, Sodium Lauryl Sulfate, Aroma, Trisodium Phosphate, Cellulose Gum, Mica, Sodium Hydroxide, Sodium Saccharin, Tocopheryl Acetate, Limonene, Sodium monofluorophosphate (1450 ppm F^-)	10568CN	Unilever Sanayi ve Ticaret Türk A.Ş ., Ümraniye, İstanbul, Turkey
Colgate Sensitive Pro-Relief	Arginine/calcium carbonate (8 wt%) Sodium monofluorophosphate (1450 ppm F^-) Hydrated silica, calcium carbonate, glycerin, 8% arginine, water, bicarbonate, flavor, cellulose gum, sodium saccharin, FD&C blue no. 1	0168BR12IA	Colgate Palmolive, New York, NY

Results

Figure 2 summarizes the mean μ-SBS values and standard deviations of the test groups. One-way ANOVA indicated that desensitizing toothpastes had significant effects on bond strength ($p < 0.05$). While μ-SBS values of the control group were higher than that of Signal Sensitive Expert, the values were lower than Colgate Sensitive Pro-Relief and Sensodyne Rapid. There were significant differences between application of Colgate Sensitive Pro-Relief and Signal Sensitive Expert toothpaste ($p < 0.05$). Similarly, a significant difference was noted between Sensodyne Rapid and Signal Sensitive Expert toothpaste ($p < 0.05$).

All of the failures were mixed type, including failure within cement, within dentin and adhesive between resin cement and dentin. Figure 3 shows representative SEM images of the debonded samples.

Discussion

The use of dentin desensitizing agents for reducing dentin sensitivity after crown preparation or before cementation has been shown to be an effective clinical treatment [11–13]. These agents are used to either desensitize the nerve or to decrease dentine permeability by occluding patent tubules [12,13]. However, the tubular occlusion caused by these agents might have a negative effect on bond strength of the luting agent [14,15].

A previous study by Sadek et al. [8] investigated the effect of oxalate and poly(glutamic) acid-modified, diluted ceramicrete desensitizer on dentinal tubule occlusion and found that the use of tubular occluding agents optimized bonding of hydrophobic resins to dentin. In contrast, a previous study indicated that Colgate Sensitive Pro-Relief desensitizing paste did not have a significant effect on the shear bond strength of the composites tested to enamel [16]. Similarly, a previous study by Canares et al. [17] reported that use of the 8% arginine and calcium carbonate desensitizing toothpaste had no effect on the bond strength of composites bonded to dentin. In the present study, while desensitizing toothpastes had significant effects on bond strength, only Signal Sensitive Expert toothpaste non-significantly reduced the bond strength of resin cement to dentin. Therefore, the null hypothesis that all the tested desensitizing toothpastes are able to reduce the dentin bond strength of resin cement to dentin must be rejected.

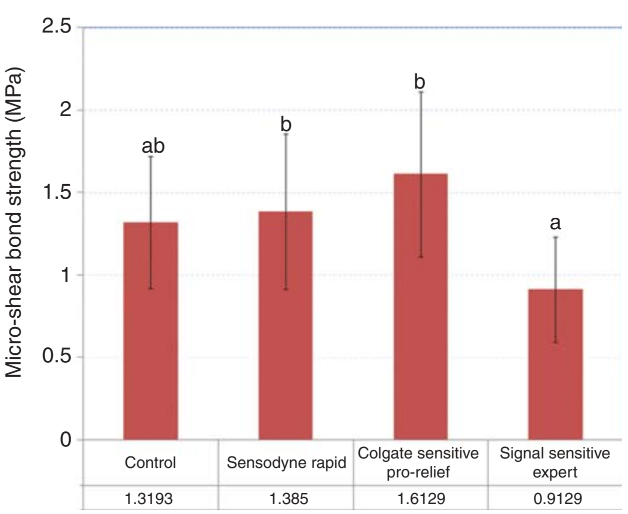

Figure 2. μ-Shear bond strength (MPa) values of resin cement to dentin. * Bars with different letters are statistically different at $p < 0.05$.

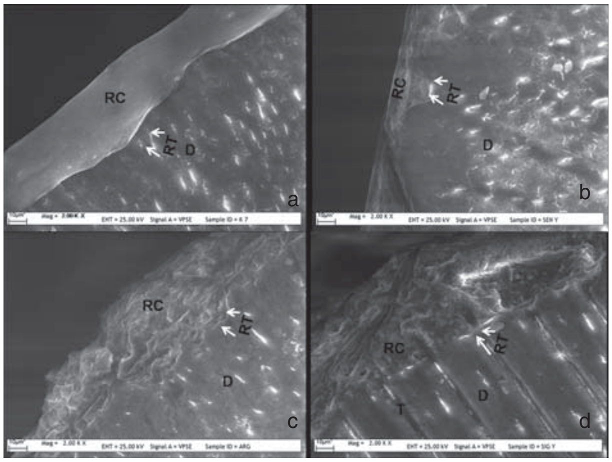

Figure 3. Scanning electron micrographs of the resin tag formation after bond strength test: (a) Control group, (b) Sensodyne Rapid Relief, (c) Colgate Sensitive Pro-Relief, (d) Signal Sensitive Expert. Original magnification ×2000, bar = 10 μm (RC: resin cement, D: dentin, RT: resin tag, T: dentin tubule).

A previous study by Lehmann and Degrange [18] evaluated the effect of a dentin desensitizer and diode laser on the bond strength of a composite resin material to dentin. They concluded that a self-etching adhesive system Clearfil SE Bond, containing 10-methacryloyloxydecyl dihydrogen phosphate monomer (MDP), was not affected by different desensitizing agents. In accordance with the results of this study, the present results might be explained by the chemical composition of Clearfil SA cement, particularly with MDP monomer. As for the comparison of the bond strength values, the bond strength values after application of Colgate Sensitive Pro-Relief and Sensodyne Rapid Relief were higher than the control group and Signal Sensitive Expert. This result might be attributed to the compatibility of these toothpastes with the Clearfil SA cement. In addition to this, Colgate Sensitive Pro-Relief and Sensodyne Rapid Relief were the compounds comprising glycerin. On the basis of this, glycerine gel was reported as an insulator in a previous study and caused an increase in bond strength values [19]. Similarly, the increase in adhesion values of Colgate Sensitive Pro-Relief and Sensodyne Rapid Relief could be attributed to glycerine content. It may be possible to avoid residues on the dentin surface by use of an insulating medium.

Desensitizing toothpastes with potassium chloride or potassium citrate have been available since 2000 and it is believed that potassium ions diffuse along the dentinal tubules to inactivate intra-dental nerves [20]. However, the desensitizing mechanism of potassium-containing toothpastes remains uncertain [21]. In the present study, potassium citrate containing Signal Sensitive Expert showed the lowest bond strength value of resin cement to dentin. The results might be related with the poor resin infiltration due to potassium citrate or hydroxyapatite crystal precipitation on the dentin surface. Furthermore, Signal Sensitive Expert comprises sodium lauryl sulfate, which has lubricating activity. As the lubrication effect increases, the friction force and as a result shear bond strength decreases [22].

Previous studies reported that the collagen network might not be required to achieve high bond strengths to dentin [23,24]. Additionally, the real role of collagen fibers in dentin adhesion is still questionable. A previous study by Baseggio et al. [25] indicated that dentin collagen does not contribute to dentin adhesion and might even interfere with bonding mechanisms, mainly due to the presence of fragile structured collagen fibers after acid etching. In the current study, after debonding, similar morphological characteristics with the collagen network were observed between surfaces brushed with the three desensitizing toothpastes(Figure 3). Our SEM observations confirmed the previous findings [23] that tubular occlusion or the collagen network does not always affect dentin bond strength [23,26].

In conclusion, this study has shown that all the tested desensitizing toothpastes had significant effects on bond strength of resin cement to dentin. Additionally, the occlusion effects of the toothpastes with respect to bond strength should be investigated.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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