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Original Research

The Effect of Different Dentin Desensitizers and Self-adhesive Resin Cements on Shear Bond Strength: In Vitro Study

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ABSTRACT

Objectives: The aim of this study is to evaluate and compare the bond strength of different dentin desensitizers and self-adhesive resin cements to dentin surfaces.

Methods: The flat dentin surfaces of 72 wisdom molar teeth were randomly divided into six groups for bond strength analysis (n=12): Group CP: No desensitizer + Primer II A&B+ Panavia F 2.0, Group CM: No desensitizer+ Primer A&B+ Multilink N, Group TP: Tokuyama Shield Force+ Primer II A&B + Panavia F 2.0, Group TM: Tokuyama Shield Force + Primer A&B+ Multilink N, Group UP: Universal dentin sealant + Primer II A&B+ Panavia F 2.0 and Group UM: Universal dentin sealent + Primer A&B+ Multilink N. The shear bond strength test was performed using a universal testing machine (0.5 mm/min). ANOVA test was used to detect significant differences at a $p < 0.05$.

Results: The results indicated that bond strength values varied according to the desensitizing and resin cement materials ($p < 0.05$). The Tokuyama Shield Force desensitizer did not affect the bond strength of the resin cements to dentin ($p > 0.05$).

Conclusion: The different types of dentin desensitizer applications affected on the shear bond strength results of the self-adhesive resin cements.

Keywords: Desensitizer, self-adhesive resin cement, shear bond strength.

INTRODUCTION

Dentin hypersensitivity (DH) is commonly described as sensitive teeth and refers to short and sharp dental pain by patients in dentistry [1]. The mechanism of dentin sensitivity is expressed with the Brännström's hydrodynamic theory [2]. This theory is relied on the the innervation of nerves by differences in pulpal pressure with the movement of the liquid in the dentinal tubules [3].

The dentinal tubules are opened to the oral environment after cavity or tooth preparation and acted as channels that transfer thermal, chemical, mechanical, and bacterial stimuli to the pulp [4]. The exposed dentinal tubules can damage the pulp tissue [4]. Dentinal tubules can be blocked for the DH treatment, and then fluid shifts and dentin hypersensitivity sensitivity can be controlled [5].

In the literature, various treatment modalities were used for DH treatment, such as fluoride treatment [6], oxalate treatment [7], arginine treatment [8,9], dental adhesives [10], and laser therapies [11].

Recently, resin-containing agents have been the most commonly used for treating DH. Resin has a physical effect on sealing the dentin tubules. Resin content occludes the dentin tubule-covered resin tags to help eliminate the hypersensitivity [12].

Self-adhesive resin cements were introduced to the markets to promote the procedures of prosthetic restoration cementation. This type of cement minimizes clinical stages and reduces postoperative sensitivity [13]. They also proposal pleasing aesthetics, adhesion of micromechanical, optimum mechanical attributes, and stability of dimensional [14]. Since these cements do not necessitate teeth surface pretreatment, they reduce application time and technical precision. These cements can diffuse and decalcify dentin because they do not contain water [15,16]. Their high hydrophilicity improves the wetting of the dentin and a low pH applying of the tooth [17].

Panavia F 2.O is a phosphate monomer-based (MDP) based resin cement and has a fluoride releasing fuction [18] and the monomer matrix of Multilink N is composed of dimethacrylate and HEMA and Multilink N Primer B contains HEMA, phosphoric acid and methacrylate monomers [19]. The bonding or sealing properties of these resin cements may be influenced by desensitizers, which contain ingredients that lead to chemical interactions with the tooth's organic tissue [20].

Desensitizing agents may be used on the tooth before cement application to avoid this hypersensitivity, but their effect on the adhesion is still suspicious [21,22].

There was limited research that assessed the effect of desensitizers on the dentin SBS of self-adhesive resin cement (SARC). Thus, the effect of dentin desensitizer (DDS) application and dentin-resin cement bond strength is still controversial, and moreover, there is no precise data about the dentin sealing protocols.

The aim of the present study was to investigate the effect of two different DDSs on the SBS of the SARCs to dentin. The null hypothesis was that DDS would not affect the bonding performance of the SARC.

Main Points;

It has been concluded that the interaction of the DDS and resin cement is the main point for the application procedures. This study will make it easier to reduce post cementation hypersensitivity and clarify the optimal indirect restoration treatment procedures.

MATERIALS AND METHODS

The Ethics Committee approved this in-vitro study of XXX University (protocol 2023/453) with to the principles of the Declaration of Helsinki.

Sample Size

For SBS analysis, the minimum sample size was defined as 24, for an effect size of 0.5, 80% power (1-β), and a 5% (α) confidence interval with G * Power 3.1.9.4 software. The effect of Tokuyama Shield Force (TSF) and Universal dentin sealant (UDS) on the SBS performance of two SARCs was assessed. The details of the used materials are shown in Table 1.

The 72 non-carious wisdom molars were cleaned and collected in distilled water at room temperature after extraction. They were embedded in a self-cured acrylic resin (Meliodent; Bayer Dental Ltd, Newbury, UK) and the occlusal regions of the crowns were removed with a water-cooled slow-speed diamond saw sectioning machine (Isomet, Buehler Ltd., Lake Bluff, IL, USA). Then the specimens were polished under water cooling using 400-, 600-, and 1000-grit silicon carbide abrasive papers for 30 seconds to standardize the surfaces.

The flat-prepared dentin specimens (n=72) were randomly divided into three groups; the first group was the control group (n=24). Two DDSs were applied to the two experimental groups, respectively. The DDSs used were Tokuyama Shield Force Plus (Light-cured desensitizer, Tokuyama, Japanese) and Universal Dentin Sealent (Ultradent) (n=12).

The study groups

- Group CP (Control group): No desensitizer+ Primer II A&B+ Panavia F 2.0 (n=12)
- Group CM (Control group): No desensitizer+ Primer A&B+ Multilink N (n=12)
- Group TP: Tokuyama Shield Force+ Primer II A&B + Panavia F 2.0 (n=12)
- Group TM: Tokuyama Shield Force +Primer A&B+ Multilink N (n=12)
- Group UP: Universal dentin sealant + Primer II A&B+ Panavia F 2.0 (n=12)
- Group UM: Universal dentin sealent+ Primer A&B+ Multilink N (n=12) (Table 2).

Table 1. Compositions and brands for the used materials

Brand	AbbrevIatIon	Chemical compostIon	Manufacturer
Tokuyama Shield Force	TSF	Phosphoric acid monomer, Bis-GMA, TEGDMA, HEMA, camphorquinone, alcohol and purified water (The pH level immediately after dispensing is approximately 2.0).	Tokuyama Dental Corporation, Taitou-ku, Tokyo, Japan
Universal Dentin Sealent	UDS	Nonpolymerizable, high molecular weight resin in an ethanol	Ultradent, South Jordan, Utah, USA
Panavia F 2.0	PF	Paste A: Methacrylate, MDP, quartz-glass, microfillers, photoinitiator Paste B: Methacrylate, barium glass, sodium fluoride, chemical initiator	Kuraray, Noritake Dental, Kurashiki, Japan
Multilink N	MN	Dimethacrylate and HEMA, barium glass, ytterbium trifluoride and spheroid mixed oxide	Ivoclar,Vivadent, Schaan/Liechtenstein
Multilink Primer A	MPA	aqueous solution of initiators	Ivoclar, Vivadent Schaan/Liechtenstein
Multilink Primer B	MPB	HEMA, phosphonic acid and methacrylate monomers.	Ivoclar, Vivadent Schaan/Liechtenstein

Abbreviations: Bis-GMA: bisphenol A glycidyl methacrylate; TEGDMA: triethyleneglycol dimethacrylate; MDP: 10- methacrylate oxydecyl dihydrogen phosphate; HEMA: 2-hydroxyethylmethacrylate

Table 2. Study Groups

	Groups
Control	Group CP (No desensitizer+Primer II A&B+ Panavia F 2.0)
	Group CM (No desensitizer+ Primer A&B+ Multilink N)
Tokuyama Shield Force	Group TP (Primer II A&B + Panavia F 2.0)
	Group TM (Primer A&B+ Multilink N)
Universal dentin sealent	Group UP (Primer II A&B+ Panavia F 2.0)
	Group UM (Primer A&B+ Multilink N)

Applying Protocols

TSF application: The dentin surfaces were initially slightly dried. The dentin was not desiccated. One or two drops of desensitizer were dispensed into the dispenser. Generous amounts of the desensitizer were applied, left undisturbed for 10 seconds, and then wiped off. A light-blocking plate protected the dispensed desensitizer and the inserted applicator from ambient light before the application. The air drying was used by using an oil-free air/water syringe. Applying weak airflow continuously to the desensitizer surfaces until the runny desensitizer stayed in the same position without any movement (for 5 seconds). A strong airflow was used for 5 seconds or more. The curing light tip was cured (600 mW/cm2) on the surface for 10 seconds or more.

UDS application: Because of its high viscosity, the dentin surfaces were thoroughly isolated and dried, and Universal Dentin Sealant's flow was verified before applying it to the dentin surfaces. A thin coat of USD was used for the dentin and gently air-dried (5-10 seconds).

Bonding Protocols

Panavia F 2.0 application: Dentin surfaces were air dried for 5 sec, then mixed ED primer II A and B) were mixed in equal amounts, waited 30 sec, then gently air dried, dispensed, and mixed equal amounts of paste and applied.

Multilink N application: One drop of Primer A and, one drop of Primer B were mixed and applied to the dentin, then 30 sec waited. A silicone mold was positioned at each specimen's center of to provide standardization the adhesive area.

The Panavia F and Multilink N resin materials were placed into the to the silicone molds with a diameter of 5 mm and a length of 2.5 mm respectively, for each species and photopolymerized for 30 seconds (20 sec per, 5 sec per surface) using a light curing device (Lite Q LD-107; Monitex Industrial, Taipei, Taiwan) for each resin types of cement.

A scalpel was used to remove the silicone molds, and excess material was removed after polymerization. Then all samples were kept in distilled water at 37°C for 24 hours. After that, they were aged for 5000 thermalcycles (5 -55°C, 20s dwell, and transfer times) in each bath (Thermocycler; SD Mechatronik, Westerham, Germany).

Shear Bond Strength (SBS test)

The samples (n = 12) were positioned into a universal testing device (Shimadzu Corporation, Kyoto, Japan). SBS tests were applied at a 0.5 mm/min crosshead speed with a knife-edge-shaped apparatus between dentin and resin cement. The shear load was performed until the failure occurred, and the measurement was noted in Newtons (N). The shear-bond force was recorded digitally, and SBS was calculated according to the following formula and expressed in MPa: Stress= Failure Load (N) / Surface Area (mm^2).

Statistical Analysis

The Shapiro–Wilk test was used to check the conformity of continuous variables with normal distribution. One-way variance analysis and LSD tests were used to compare two independent measures across normally distributed variables. Analyses were conducted using IBM SPSS 22 at $p<0.05$.

RESULTS

SBS Results

The SBS's mean levels and standard deviations (SD) for all groups are shown in Table 3, and p values are shown in Table 4.

The highest SBS results among all groups were in Group CM (13.32 ± 1.47)(No desensitizer+ Primer A&B+ Multilink N)), and the lowest SBS results were in Group UP (0.76 ± 0.14) (Primer A&B+ Multilink N) ($p <0.05$).

The UDS decreased the SBS results within the adhesive cement ($p < 0.05$).

Table 3. SBS values (MPa)

Groups	MEAN ± SD
Group CP	8.39 ^{a} ±1.12
Group CM	13.32 ^{b} ±1.47
Group TP	7.84 ^{a} ±1.47
Group TM	12.95 ^{b}±2.22
Group UP	0.76 ^{c} ±0.14
Group UM	0.80 ^{c} ±0.25

*Mean and standard deviations ± (SD)in megapascals (MPa) of shear bond strength (SBS) values and statistical differences between groups (n=12)

*Different letters within the lines indicate statistically significant differences.

Table 4. P values

Groups	P
Group CP - GROUP CM	**0.001**
Group CP – Group TP	0.317
Group CP – Group TM	**0.001**
Group CP – Group UP	**0.001**
Group CP – Group UM	**0.001**
Group CM – Group TP	**0.001**
Group CM – Group TM	0.505
Group CM – Group UP	**0.001**
Group CM– Group UM	**0.001**
Group TP – Group TM	**0.001**
Group TP – Group UP	**0.001**
Group TP – Group UM	**0.001**
Group TM – Group UP	**0.001**
Group TM – Group UM	**0.001**
Group UP – Group UM	0.940

*$p<0.05$ indicate statistically significant differences

Failure Type Results

After the shear load was applied to the specimens, the fractured areas were examined under a stereomicroscope (Leica model, Leica QWinV.3 software; Leica Microsystem Imaging Solutions, Cambridge, UK) at 15× magnification. The failure type analysis revealed that the adhesive type of failure was the most predominant failure type within all groups. The adhesive failures were found on 80.55% of specimens. Cohesive 0 (0%) and mixed 19.44 % fractures have been seen for groups (Table 5).

Table 5. Frequency of types of bond failure for each group (%)

	Group CP	Group CM	Group TP	Group TM	Group UP	Group UM	Total Frequency and Percent
Adhesive	8/12 (66.66%)	9/12 (75%)	8/12 (66.66%)	9/12 (75%)	12/12 (100%)	12/12 (100%)	58/72 (80.55%)
Cohesive Dentin	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)
Mixed	4/12 (33.33%)	3/12 (25%)	4/12 (33.33%)	3/12 (25%)	0/12 (0%)	0/12 (0%)	14/72 (19.44%)

Group CP: *Group CP (No desensitizer+Primer II A&B+ Panavia F 2.0)**; Group CM:*** *Group CM (No desensitizer+ Primer A&B+ Multilink N)**; Group TP:*** *Group TP (Primer II A&B + Panavia F 2.0)**; Group TM:*** *Group TM (Primer A&B+ Multilink N)**; Group UP:*** *Group UP (Primer II A&B+ Panavia F 2.0)**; Group UM:*** *Group UM (Primer A&B+ Multilink N) statistically significant differences.*

DISCUSSION

The aim of this study was to evaluate the effect of two different DDSs on the SBS of the SARCs to dentin, and the null hypothesis partially rejected. Following the application of TSF desensitizer and using SARC as Panavia F 2.0 and Multilink N, there was no increase/decrease in SBS. In contrast, using UDS decreased the SBS with the Panavia F 2.0 and Multilink N.

Many dentin coating methods are being investigated in the literature. Samartzi et al. found that resin-coated dentin lets dentin fluid pass through polymerized resins [20]. Therefore, the use of either adhesive of three-step or two-step self-etching primer adhesives is suggested by researchers [20].

Magne recommended using flowable composite over unfilled adhesives as an alternative to the use of filled adhesives and covering the resin-sealed preparation with glycerine gel [23].

In a clinical study, Sayed et all stated the clinical satisfaction results after tooth preparation due to the treatment with Gluma (Heraeus Kulzer, Hanau, Germany), Shield Force Plus (Tokuyama Dental America Inc., San Diego, CA, USA), and Telio CS (Ivoclar Vivadent, Schaan, Liechtenstein) desensitizing agents and all of these desensitizers were found to be effective in reducing the dentin sensitivity, as reported by the VAS scores throughout the pre and post-cementation visits [24].

Due to its simplicity and possibility of digital recording of the SBS test, it is most commonly used, and many conditions are investigated in the literature for dental adhesives [4,13].

On the other hand, the bond effect of newly produced desensitizers on dentin is still being investigated. From past to present, desensitizing agents are commonly treated for the aim of controlling pain, making much more comfortable making dental procedures for patients who need fixed prostheses; there are several in-vitro studies investigating the effect of the sensitizing agents or sealing materials on the SBS with different cements type [25,26,27].

Some studies examining the effect of desensitizing agents between the self-adhesive resin and dentin interface report conflicting results [4,22]. For example, Stawarczyk et al. investigated the effect of Gluma Desensitizer on SBS of conventional and self-adhesive resin cements after water storage and thermocycling, and they reported that Gluma Desensitizer showed increased SBS after aging conditions with self-adhesive resins (ranging from 7.4 ± 1.4 to 15.2 ± 3) and Panavia 21 and Gluma interaction showed a significant decrease thermocyling compared with initial values [4] and as a similar result Sailer reported that Gluma has a positive effect with Rely X Unicem [28] and in this study, SBS results were not effected for TSF groups and were decreased for UDS groups with the SARCs.

Dewan et all investigated the effect of desensitizing agents on the bond strength following cementation of zirconia crowns by applying self-adhesive resin and HEMA-containing sensitizers (Gluma, Shield Force Plus, and Telio CS) and Gluma served better bond strength results [22].

Tokuyama Shield Force Plus is a resin-based light-cured, flüoride-releasing desensitizer designed to treat hypersensitive dentin [29]. It has been stated that the hydrophilic characterization provided by HEMA in Shield Force Plus desensitizer agent enhances bonding to structure [24]. A condensation reaction occurs between HEMA and water evaporation, resulting in a better bond [24]. In the present study, HEMA content was an advantage for TSF groups. TSF served similar results with the control groups with two SARCs and more successful results than all UDS groups, supporting the results of these studies.

The manufacturer explains the UDS as a biocompatible, non-polymerizable, high molecular weight resin in an ethanol carrier (UDS instructions) [30]. In the literature, limited studies have investigated UDS.

Milia et al. resin investigated the short-term response of these three materials, including UDS, and reported that the morphology of UDS on the tooth structure brought about a dense barrier-like structure with tag-like structures resembling demineralized tubular dentin [31].

Pinna et al. Vertise flow (self-adhesive composite) was considered a match for UDS sealant because the performance of flowable composites can be comparable to resin-based sealants [32].

When we applied the UDS and TSF to our species, we experienced that UDS had a higher viscosity than the TSF. Pashley et al. reported that adhesion efficiency is related to the viscosity and degree of conversion of the adhesive, which may negatively affect the penetration of the monomers into the interfibril spaces [33].

Furthermore, Zhang et al. reported that the permeability would be the critical consideration in incomplete infiltration of the bonding and effecting the SBS to dentin [34].

Therefore, we assume that viscosity and insufficient permeability had negatively affected the bond strength for all UDS groups, and TSF and UDS groups served statistically different bond strengths because of the differences in their ingredients or chemical activation, dissolution resistance capacity, and the different dissolving quality and precipitation level in the dentinal tubules. Adhesive failures were the primary failure type observed for all UDS and TSF groups. This has led to apparent results similar to Dewan et al. [22]. They reported adhesive failure was seen for 80% in the Gluma and Telio groups, 70% in the no-treatment group, and 90% in the ‘’Shield Force “ group for Rely X U-200. Various factors affect in vitro SBS, including the type and age of the dentin, mineralization degree, adhered dentin surface, test conditions, and environment of storage [35]. Desensitizing agents are different in ingredients, functional or cross-linking monomers, chemical activation, and solvents, including inhibitors and activators, and can affect the bonding quality of resin-type cement. All these factors may have an effect on the SBS.

Limitations

This study has limitations in that it can be mentioned that not using distilled water instead of artificial saliva to mimic intra-oral conditions fully. With the limitations of this in vitro study, further investigation is required about desensitizing agents' ability to bond and seal to tooth surfaces.

CONCLUSIONS

Although the use of DDS before applying the bonding agent may reduce postoperative sensitivity, it was observed that the SBS may decrease depending on the bonding agent used.

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