

The Effect of Desensitizing Treatments on the Bond Strength of Resin Composite to Dentin Mediated by a Self-etching Primer

T Akca • AR Yazici • Ç Çelik
G Özgünlaltay • B Dayangaç

Clinical Relevance

Desensitizing treatments, except for self-etching adhesives, might have an adverse effect on the bond strength of a resin composite to dentin mediated by a self-etching primer. Therefore, it might be important for clinicians to evaluate previous desensitizing treatments.

SUMMARY

This study evaluated the bond strength of resin composite to dentin, mediated by a self-etching adhesive, following the application of various

Taner Akca, DDS, PhD, assistant professor, private practice, Mersin, Turkey

*A Rüya Yazici, DDS, PhD, associate professor, Hacettepe University, Faculty of Dentistry, Department of Conservative Dentistry, Ankara, Turkey

Çigdem Çelik, DDS, PhD, research assistant, Baskent University, Faculty of Dentistry, Department of Conservative Dentistry, Ankara, Turkey

Gül Özgünlaltay, DDS, PhD, professor, Hacettepe University, Faculty of Dentistry, Department of Conservative Dentistry, Ankara, Turkey

Berrin Dayangaç, DDS, PhD, professor, Hacettepe University, Faculty of Dentistry, Department of Conservative Dentistry, Ankara, Turkey

*Reprint request: 06100, Sıhhiye, Ankara, Turkey; e-mail: ruyay@hacettepe.edu.tr

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dentin desensitizing treatments and artificial saliva storage.

The buccal cervical areas of 24 extracted human third molars were ground flat to expose cervical dentin. The dentin surfaces were polished with 1200-grit SiC paper, then the teeth were randomly assigned to six groups, five desensitizing treatments and one control: Group I-VivaSens; Group II-Fluor Protector; Group III-Isodan; Group IV-Futura Bond NR; Group V-Nd:YAG laser and Group VI-Control (without application of a desensitizing agent). After applying the desensitizing treatments and storing the molars in artificial saliva for 14 days at 37°C, Futura Bond NR was used to bond resin composite to dentin. TPH composite build-ups were constructed incrementally to a height of 5 mm. The teeth were sectioned to obtain bonded slices of 0.7 mm thick specimens containing the resin-composite joint. The specimens were then trimmed into an hourglass shape and sub-

sequently subjected to microtensile testing at a crosshead speed of 1 mm/minute. The data were analyzed using the Kruskal-Wallis analysis and multiple comparisons test.

The control (Group VI) and Futura Bond NR self-etching treatment (Group IV) group yielded statistically significant higher bond strength values than the other desensitizing treatment groups tested ($p<0.005$). While pretreatment of dentin surfaces with desensitizing agents (Fluor Protector, VivaSens and Isodan) and laser (Nd:YAG) reduced the bond strength values of the resin composite, higher bond strengths were achieved using a self-etching adhesive (Futura Bond NR) as a desensitizing agent.

INTRODUCTION

Dentin hypersensitivity is the most common patient complaint encountered in the dental practice. Hypersensitivity generally occurs at the cervical area of teeth and is caused, not only by chemical erosion, but also by mechanical abrasion, occlusal stresses and gingival recession.¹⁻² The most widely accepted explanation for dentin hypersensitivity is the hydrodynamic theory,³ where the movement of fluids or semi-fluid materials in dentin tubules transmits peripheral stimuli by deforming sensory nerves in the pulp, which causes pain.

There are several treatments available for hypersensitivity. These treatment modalities are believed to reduce the symptoms of dentin hypersensitivity by either reducing dentin permeability and fluid flow by occluding dentin tubules, thus blocking the neural stimulus and response⁴ or by intercepting the neural response by chemical intervention.⁵⁻⁷ The most commonly used agents are fluoride-containing agents that have been shown to be effective in relieving the pain of tooth sensitivity.⁸ Treatment with fluoride varnish forms a protective layer of calcium fluoride, which prevents dentinal fluid flow, thereby reducing dentinal sensitivity.⁸ The effectiveness of dentin hypersensitivi-

ty treatment with fluoride varnishes has been reported in various clinical studies.⁹⁻¹⁰

The use of self-etching adhesives to treat hypersensitivity has gained popularity in the last few years. These systems use hydrophilic acidic monomers, which simultaneously demineralize and penetrate enamel and dentin and, therefore, are less likely to create discrepancies between the depth of demineralization and that of resin infiltration. As these systems do not completely resolve or remove the smear layer, they partially integrate into the hybrid layer,¹¹ reducing post-operative sensitivity associated with removal of the smear layer and smear plugs.¹²

Another choice of treatment for hypersensitive dentin is to use lasers. The mechanism of effect is based on the coagulation and precipitation of plasma proteins in dentinal fluid.¹³ Another possible explanation for laser effectiveness is that thermal energy delivered from lasers may alter intradental nerve activity.¹⁴

The effects of laser irradiation on relieving the pain of hypersensitive dentin have been demonstrated by a number of clinical investigations.¹⁵⁻²¹

Sometimes, these treatments are not permanent and patients may continue to experience pain from external stimuli. At this point, clinicians usually restore cervical lesions with glass ionomer or resin composites. There are conflicting reports on the effects of these desensitizing agents on the bond strength of adhesive restorations. Therefore, this *in vitro* study evaluated the effect of desensitizing agents on the bond strength of resin composite to dentin mediated by a self-etching adhesive.

METHODS AND MATERIALS

In this study, 24 human third mandibular molars stored at 4°C in an aqueous solution of 0.5% Chloramine T were used within one month of extraction. The buccal surface of each tooth was ground parallel to the long axis of the tooth to expose a flat surface of cervical dentin. The flat dentin surface was polished

Table 1: Desensitizing Treatments Used		
Desensitizing Treatments	Manufacturer	Composition
VivaSens	Vivadent, Schaan, Liechtenstein	Ethanol, water, hydroxypropyl cellulose, methacrylate modified polyacrylic acid, polyethylene glycol dimethacrylate, phosphonic acid-methacrylic acid, potassium fluoride
Fluor Protector	Vivadent, Schaan, Liechtenstein	1% Difluorosilane, 0.1% F
Isodan	Septodont of Canada Ins, Cambridge, ON, Canada	Potassium nitrate, sodium fluoride, HEMA, excipients
Futura Bond NR	Voco, Cuxhaven, Germany	Bis-GMA, hydroxyethyl-methacrylate, BHT, ethanol, organic acids, fluorides
Nd:YAG laser	Fotona Fidelis Plus II, Fotona dd, Ljubljana, Slovenia	N/A

with 320-600-1200 grit silicon carbide paper (SiC) under copious running water.

After the dentin surface was thoroughly rinsed with water, the teeth were randomly divided into six groups, five desensitizing treatment (Table 1) and one control of four teeth each:

Group I: VivaSens (Vivadent, Schaan, Liechtenstein) was applied to the dentin surface and left undisturbed for 10 seconds.

Group II: Fluor Protector (Vivadent, Schaan, Liechtenstein) was applied to the dentin surface for 10 seconds.

Group III: Isodan (Septodont of Canada Inc, Cambridge, ON, Canada) was applied to the dentin surface and spread gently with an air jet. It was reapplied two or three times until a shiny surface was obtained.

Group IV: Futura Bond NR (Voco, Cuxhaven, Germany) was applied to dentin for 20 seconds and dried with an air jet for 5 seconds, then light polymerized for 10 seconds.

Group V: The dentin surface was irradiated with a pulsed Nd:YAG laser (Fotona Fidelis Plus II, Fotona dd, Ljubljana, Slovenia) at 10 Hz, yielding an average power of 1 W. The laser tip was swept mesiodistally, with a total irradiation time of 60 seconds to simulate clinical manipulation. The laser was reapplied one week later.

Group VI: No desensitizing agent was applied on the prepared dentin surfaces.

After storing all of the prepared specimens in artificial saliva for 14 days at 37°C, each was rinsed with water and air dried for five seconds with an air/water syringe. A self-etching adhesive, Futura Bond NR, was applied to the treated dentin surfaces to bond resin composite according to the manufacturer's instructions. Composite build-up using TPH (Dentsply, Caulk) was incrementally built up to a height of 5 mm, and each layer was light-cured for 40 seconds (Hilux, Benlioglu, Ankara, Turkey). The light-curing power was monitored before each irradiation to ensure light output in excess of 400 mW/cm².

The specimens were stored in water at 37°C for 24 hours, then sectioned into five to seven slabs (0.7-mm-thick) in a buccolingual direction parallel to the long axis using a water-cooled low-speed diamond saw

(Isomet, Buehler Ltd, Lake Bluff, IL, USA). The specimens were then trimmed into an hourglass shape using a super-fine diamond bur to create a bonding surface area approximately 1 mm². Next, according to the location of the pulp chamber, 20 to 28 slabs were selected to achieve an estimated tubule direction to the bonded interface. The specimens were then attached to Bencor Multi-T apparatus (Danville, Engineering Co, Danville, CA, USA) and underwent tensile stress using a universal testing machine (Instron Corp, Canton, MA, USA) at a crosshead speed of 1 mm/minute. The microtensile bond strengths (μ TBS) were determined by computing the ratio of maximum load divided by the bonded surface area. When the specimens failed before actually being tested, the mean was determined for the specimens that survived the specimen preparation, noting the explicit number of pretest failures.

The Kruskal-Wallis analysis and multiple comparisons test were used to determine statistical differences in μ TBS between the desensitizing treatment and control groups at a level of $\alpha=0.05$.

RESULTS

Table 2 lists the mean microtensile bond strengths and standard deviations. The results of the Kruskal-Wallis test indicated significant differences in mean values of bond strength for the different desensitizing treatment groups. For the control group, the μ TBS was 13.02 MPa, which was not significantly different from the Futura Bond NR group (Group IV). The control (Group VI) and Futura Bond NR's group (Group IV) bond strength values were statistically higher than the other groups tested ($p<0.005$). Statistically significant differences were not observed among the other four treatment groups.

DISCUSSION

Dentin hypersensitivity is an extremely widespread phenomenon characterized by patients complaining about pain that is triggered by drinking hot or cold beverages, eating sweet or sour food, touching a tooth or breathing in cold air. Many different desensitizing treatment methods have been suggested to relieve this pain. While some methods are successful, sometimes their effects are not permanent and, in some cases, lasting only for a short period of time, with the hypersensitivity persisting. Therefore, clinicians need to restore

Group #	1	2	3	4	5	6
	VivaSens	Fluor Protector	Isodan	Futura Bond NR	Nd:YAG Laser	Control
μ TBS (MPa)	3.12 (1.16) ^a	5.41 (1.97) ^a	5.57 (2.07) ^a	15.72 (13.06) ^b	5.29 (3.25) ^a	13.02 (9.38) ^b
Pre-testing failures (n)	(3)	(2)	(4)	(0)	(1)	(3)
Values are expressed as means (\pm standard deviations) in MPa. Mean values with the same superscript letters are not significantly different ($p=0.000$, KW:31.772)						

these hypersensitive dentin surfaces following unsuccessful treatment. An important question that needs to be answered is how these desensitizing agents or treatments might affect the bonding strength of a resin composite to pretreated dentin surfaces.

VivaSens reduces the hypersensitivity of dentin by sealing the dentinal tubules. It contains organic acids, such as phosphonic acid methacrylate, and solvents, such as ethanol, which induce the precipitation of proteins in the dentin liquid. Moreover, the sealing effect is enhanced by co-precipitating polyethylene glycol dimethacrylate (PEG-DMA), which VivaSens also contains. Phosphonic acid methacrylate and methacrylate-modified polyacrylic acid form Ca-salts that form precipitates in the dentin tubules. In addition, the potassium ions of its fluoride component support precipitation of the salts.²²

Fluor Protector is a fluoride-containing protective varnish for the desensitization and prevention of caries. This varnish forms calcium fluoride globules that block the open dentin tubules and prevent dentin fluid flow. As Fluor Protector and VivaSens promote tubule occlusion, it is not surprising that they had low bond strength values. The precipitation of microcrystals and mineral deposits into dentin tubules will prevent resin infiltration. Resin tag formation is known to increase resin-dentin bond strength. This result is supported by a previous study which concluded that, the application of a desensitizing agent (D/Sense 2) prior to bonding procedures, resulted in dramatically lower bond strengths.²³ Sengun and others²⁴ evaluated the effect of desensitizers on the bond strength of a self-etching adhesive system to caries-affected dentin. While they found that applying desensitizers prior to the bonding process significantly reduced shear bond strengths to sound dentin, the effect of desensitizers on bond strength to caries-affected dentin changed according to the chemical composition of the materials. In a study by Nystrom and others,²⁵ fluoride treatment to sound dentin has been shown to decrease the bond strength of composites.

Paes Leme and others²⁶ evaluated the occluding effect of five desensitizing agents (Oxagel, Duraphat, Desensibilize, Odahcam, Sensodyne) on human dentin tubules with SEM observations and measurements. They reported that blockage and reduction of the tubule lumen occurs as a result of the deposition of fluoride and insoluble salts.

A study by Al Qahtani and others²⁷ found that Protect desensitizer reduced the shear bond strength of dentin bonding agents to the dentin surface. These authors attributed this result to the presence of monohydrogen-monopotassium oxalate in this desensitizer, which might have been precipitated. On the other hand, they reported that application of another desensitizing

agent, Hurriseal, which contains HEMA, benzalkonium chloride and sodium fluoride, resulted in higher bond strengths. They mentioned the ability of the hydrophilic wetting agent HEMA to reopen interfibrillar spaces. Isodan was another desensitizing agent used in this study. The composition of this agent was quite similar to Hurriseal, except for the lack of benzalkonium chloride. Isodan's ingredients are HEMA, sodium fluoride and potassium nitrate. Although not statistically significant, the bond strength values obtained with Isodan treatment were higher than those obtained with VivaSens. This might be due to the presence of HEMA in this solution. It has been reported that HEMA depresses the surface tension of water and enhances monomer diffusion into dentin.²⁸⁻²⁹

Contrary to the findings of this study, Kimura and others³⁰ reported that fluoride varnish did not significantly affect the bond strength of orthodontic brackets to enamel, either with a conventional or a self-etching adhesive. However, Kimura investigated bond strength values to enamel, not to dentin.

Another desensitizing treatment used in the current study was Nd:YAG laser. Nd:YAG laser melts hydroxyapatite, which, upon cooling, can resolidify and form hydroxyapatite crystals that are larger than their initial structure.¹⁹ De Magalhaes and others³¹ investigated the efficacy of Nd:YAG pulsed laser at 1064 nm in sealing dentin tubules *in vitro* and its resulting morphological changes, using clinical parameters applicable to the treatment of dentin hypersensitivity. These authors observed the obliteration of dentin tubule openings and solidification of the dentin surface in all irradiated samples. Sipahi and others³² demonstrated that desensitizing with a laser was an efficient treatment option for the occlusion of dentin tubule apertures. Many scanning electron microscopic studies have shown that Nd:YAG laser causes closure of exposed dentin tubules.³³⁻³⁶ Low bond strength values observed with the use of laser treatment might be explained by tubule closures. As closed tubules will not allow for the penetration of resin monomers, resin tag formation will not occur.

In a recent study evaluating the influence of desensitizing procedures on dentin bond strength, specimens treated with a low-intensity laser yielded significantly low mean bond strengths.³⁷

The bonding mechanism of self-etch adhesives is based on changing the chemical composition of the substrate surface, commonly referred to as hybridization; the surface layer of dentin is partially dissolved and the resultant porosity filled with resin.³⁸ Moreover, the risk of discrepancy between the depth of dentin demineralization and hybridization is limited. In the current study, the highest bond strength values were achieved in the Futura Bond NR self-etching group (Group IV),

which was not different from the control group. This result may have been due to the bonding mechanism described above.

The results of this study cannot be directly extrapolated to clinical situations, as the absence of dentin fluid in the extracted teeth may have influenced the bond strength values. However, clinicians should be aware that previous desensitizing treatment might adversely affect the bond strength of resin composite. Therefore, further clinical studies must be conducted in order to evaluate the adverse effects of desensitizing treatments on the bond strength of restorative materials.

CONCLUSIONS

Desensitizing treatments, except for self-etching adhesive, might have an adverse effect on the bond strength of a resin composite to dentin.

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