



Effects of Different Cavity Disinfectants on Shear Bond Strength of a Silorane-based Resin Composite

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ABSTRACT

Aim: This *in vitro* study evaluated the effect of different cavity disinfection agents on bond strength of a silorane-based resin composite.

Materials and methods: Thirty-six caries-free human third mandibular molars sectioned in mesio-distal direction were mounted in acrylic resin with their flat dentin surfaces exposed. After the dentin surfaces were wet ground with # 600 silicon carbide paper, the teeth were randomly divided into 6 groups of 12 each according to the cavity disinfection agents; chlorhexidine (CHX); sodium hypochlorite (NaOCl), propolis, ozone, Er,Cr:YSGG laser and no treatment (control). After treatment of dentin surfaces with one of these cavity disinfection agents, Filtek Silorane adhesive system was applied. The silorane-based resin composite, Filtek Silorane was condensed into a mold and polymerized. After storage at 37°C for 24 hours, the specimens were tested in shear mode at a crosshead speed of 1.0 mm/minute. The results were analyzed by one-way ANOVA.

Results: No statistically significant difference was observed between the groups ($p > 0.05$).

Conclusion: The use of the tested cavity disinfection agents, chlorhexidine, sodium hypochlorite, propolis, ozone and Er,Cr:YSGG laser did not significantly affect the dentin bond strength of a silorane-based resin composite, Filtek Silorane.

Clinical significance: Cavity disinfectant applications did not affect the dentin bond strength of a silorane-based resin composite.

Keywords: Cavity disinfectants, Chlorhexidine, Sodium hypochlorite, Propolis, Ozone, Er,Cr:YSGG laser, bond strength

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INTRODUCTION

Conventional removal of carious tissue and cavity preparation procedures do not guarantee the complete

elimination of oral cariogenic bacteria that might be entrapped within the dentin tubules or the smear layer, which may induce secondary caries or pulpal inflammation.¹ For these reasons, elimination of the bacteria from the cavity surfaces is of major importance. Disinfectant solutions are in general use to reduce or eliminate bacteria from cavity preparations. Some antibacterial solutions have been tested as cavity disinfectants are chlorhexidine digluconate (CHX), sodium hypochlorite (NaOCl), and hydrogen peroxide (H₂O₂).²

Chlorhexidine has been widely used as an antimicrobial agent as well as for disinfection before the placement of restorations.³ CHX is a bis-bis-guanide that acts by adsorbing onto the cell wall of microorganisms resulting in leakage of intracellular components.⁴ CHX has a broad-spectrum antimicrobial activity,⁵ targeting both gram-positive and gram-negative microbes and is biocompatible.⁶ Chlorhexidine is the most potent antimicrobial agent to combat *Streptococcus mutans*. It has been found to be effective in reducing levels of *S. mutans* found in occlusal fissures and on exposed root surface.⁷ Its efficacy in caries prevention has been shown in many clinical trials.^{8,9}

The most commonly used antimicrobial agent up to now has been NaOCl. Depending on the testing methodology and the adhesive system composition, the application of sodium hypochlorite may increase, decrease, or have no effect on bond strengths.^{10,11} In a study conducted by Taniguchi et al,¹² it was reported that NaOCl pretreatment for 30s significantly reduced the bond strengths of self-etch adhesive systems to sound dentin, while there were no significant differences in dentin bond strength values between normal dentin and NaOCl-15s treated groups.

Propolis is a resinous hive substance by honeybees from products collected from plants. It is known to possess valuable antimicrobial, antiviral, fungicidal, local anesthetic,

antiulser, immunostimulating, hypotensive and cytostatic properties.¹³ Propolis has been used as a remedy for treatment of many diseases in folk medicine since ancient times. A number of studies have been conducted, mainly on animals and to a lesser extent on humans, to investigate propolis in different dental fields.¹⁴⁻¹⁶ Ethanol extract of propolis produces favorable properties for endodontic use, such as promoting bone regeneration and inducing hard tissue bridge formation in pulpotomies or pulp capping.^{13,17}

Gasiform ozone has been introduced in dental practice due to its antimicrobial potential against common oral pathogens. Clinical studies have assessed the effect of ozone for the treatment of occlusal¹⁸ and root caries¹⁹ and, more recently, the application of ozone on dental hard tissue prior to adhesive restorations.^{20,21}

Another alternative treatment protocol for disinfection the cavities is the use of lasers. The Er,Cr:YSGG laser uses hydrokinetic energy. As a result of this hydrokinetic energy, the Er,Cr:YSGG laser may have ability to disinfection.²² Er,Cr:YSGG laser irradiation is able to remove the debris and smear layer efficiently.²³ Removal of the smear layer serves to eliminate the microorganisms and thus prevent residual caries. Therefore, some researchers believe that the laser may be able to provide restorations with greater bond strength and greater longevity than those obtained by the conventional method.^{24,25}

Two major properties of dental composites that remain to be improved are polymerization shrinkage and related polymerization stress. Naturally, the best way to avoid shrinkage stress is to use nonshrinking resins. Recently, a low-shrinking composite, Filtek Silorane was introduced. Siloranes replace the methacrylates in the resin matrix of dental composites. The ring-opening chemistry of the resin reduces shrinkage of the composite below 1%. Filtek Silorane comes with a two-step self-etch adhesive, commercialized as 'Silorane System Adhesive (SSA) that is specific to this particular chemistry.²⁶

A potential problem in the use of a disinfectant before dentin adhesives is the possibility of an adverse interaction on the bond strength of the resin composites. The objective of this study was to compare the effects of different disinfection agents; CHX, NaOCl, propolis, ozone and Er,Cr:YSGG laser on shear bond strength of a silorane-based resin composite. The null hypothesis was different disinfectant agents do not affect the shear bond of a silorane-based resin composite to dentin.

MATERIALS AND METHODS

Thirty-six caries-free human third mandibular molars were stored in 0.5% chloramin solution at 4°C and used within

one month after extraction. The teeth were sectioned in mesio-distal direction with a low-speed diamond disk (Buehler; Lake Bluff, IL, USA) under water coolant. The sectioned teeth were embedded in autopolymerizing acrylic resin and a flat dentin surface was exposed (Fig. 1). The exposed dentin surfaces were further flattened on wet using a 600-grit Si-C paper for 60 seconds to standardize the smear layer. The teeth were then rinsed with distilled water to remove any debris and were randomly divided into 6 groups of 12 teeth each.

Group I: A 2% chlorhexidine gluconate (CHX, Drogosan, Ankara, Turkey) solution absorbed cotton pellet was applied to dentin for 20s.² The dentin surfaces of the teeth were then dried with air for 10s (Fig. 2).

Group II: The surfaces of specimens were treated by rubbing a 2.5% sodium hypochlorite (NaOCl) solution absorbed cotton pellet for 20s.² The dentin surfaces of the teeth were then rinsed and dried with air for 10s (Fig. 3).

Group III: The surfaces of specimens were treated by rubbing a one drop 30% propolis absorbed cotton pellet for 20s.² The dentin surfaces of the teeth were then dried with air for 10s. The propolis sample was collected from Kayseri

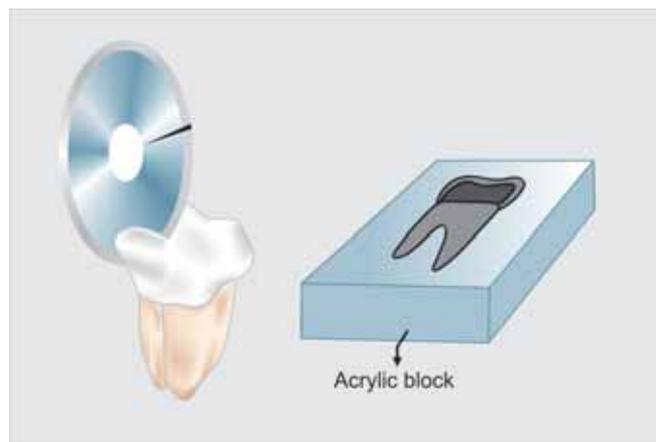


Fig. 1: Specimen preparation

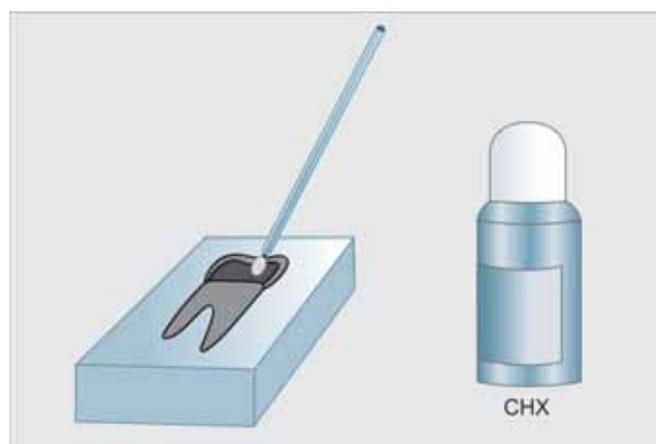


Fig. 2: Chlorhexidine gluconate (CHX) application

(Central Anatolia), in Turkey. The hand-collected propolis sample was kept desiccated in the dark until it was processed. Subsequently, 30 g crude propolis was dissolved in 70% ethanol by shaking for 3 days. The aqueous-ethanol extract was filtered through a Whatman 1 paper and evaporated at 50°C. The resin obtained was dissolved in 70% ethanol to 30% ethanol extract of propolis (EEP) (Fig. 4).

Group IV: Ozone (Ozonytronx, Biozonmylius, GmbH Mymed, Germany) was used to generate ozone gas. Ozone was applied to the dentin surface with PA tip, adjusting device to the third level for 30s (Fig. 5).

Group V: The dentin surfaces were irradiated with a Er,Cr:YSGG laser (Waterlase MD, Biolase, San Clemente, California, CA, USA) emitting photons at a wavelength of 2.780 nm and a pulse duration of 140 microseconds. The laser energy was delivered through a sapphire tip, 600 μm in diameter and 6 mm long, positioned perpendicular to the dentin surface. A power of 0.75 W (15% air, 15% water) with 20 Hz was used in focus mode at a 1-2 mm focal distance. The laser was applied to dentin surfaces 5 times for 10s application with 5s intervals (Fig. 6).

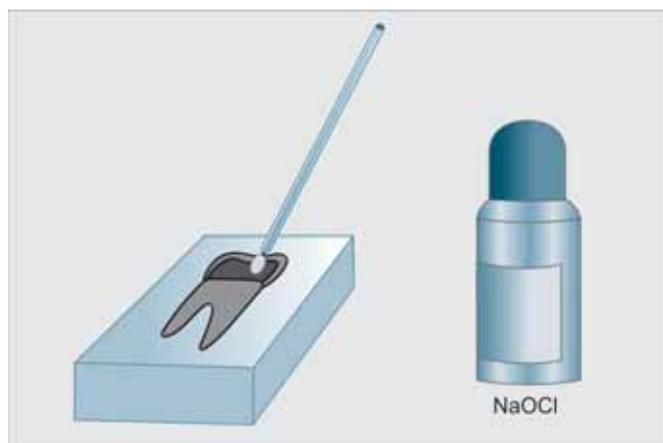


Fig. 3: Sodium hypochlorite (NaOCl) application

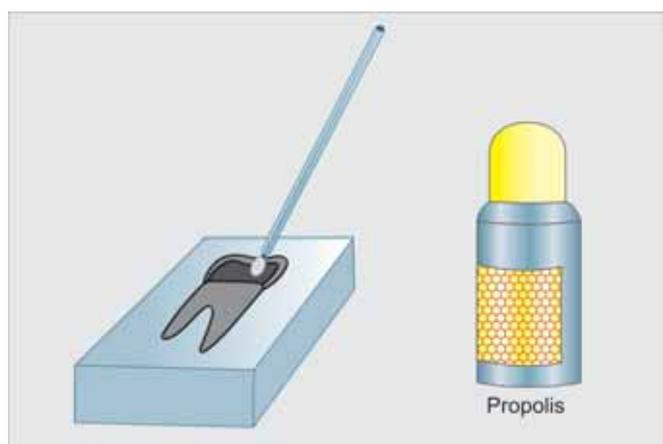


Fig. 4: Propolis application

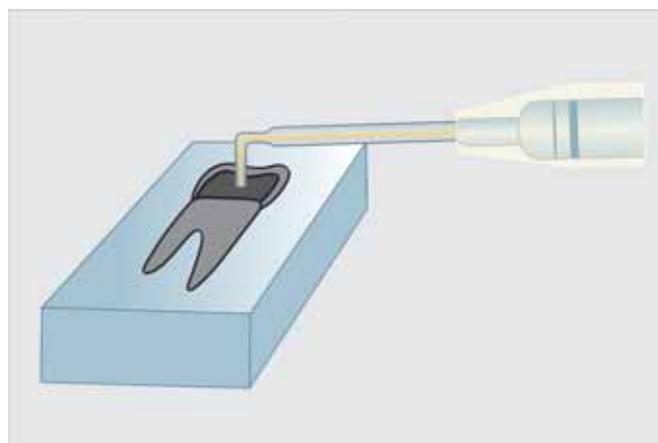


Fig. 5: Ozone application

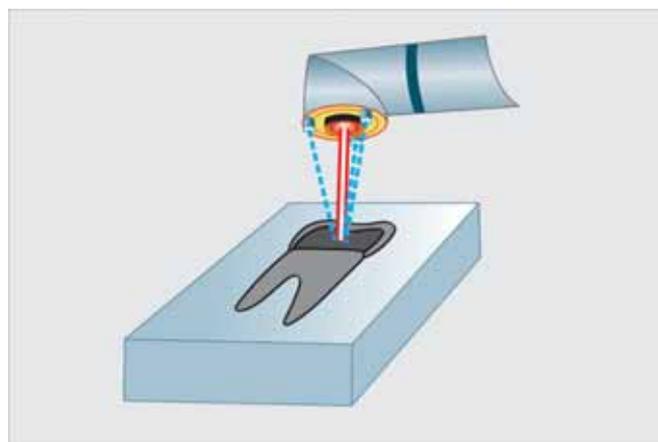


Fig. 6: Er,Cr:YSGG laser application

Group VI: The specimens were not treated with any cavity disinfectant and served as control (Fig. 7).

After treatment of the dentin surfaces, Silorane Self-Etch Primer (3M ESPE, St Paul, MN, USA) was applied and rubbed for 15s. The dentin surface was dried with air and then light cured for 10s using a quartz-tungsten halogen light (Hilux, Benlioglu, Ankara, Turkey) set at 550 mW/cm^2 . Silorane bond was applied to the dentin surface and light cured for 10s using the same light-curing unit (Fig. 8). Transparent gelatin capsules (2.5 mm diameter, 2 mm high) were used to form and hold the restorative resin onto the dentin surface. A silorane-based resin composite (Filtek Silorane, 3M ESPE, St Paul, MN, USA) was condensed into the capsule and cured for 40s (Table 1) (Fig. 9). Following storage in distilled water at 37°C for 24h, the specimens were tested in shear mode using a knife-edge testing apparatus in a universal testing machine (Lloyd, Hampshire, UK) at a crosshead speed of 1.0 mm/minute (Fig. 10). The shear strength bond values in MPa were calculated from the peak value load at failure divided by the specimen surface area.

One-way ANOVA was used for multiple comparisons of the bond strengths for the different groups.

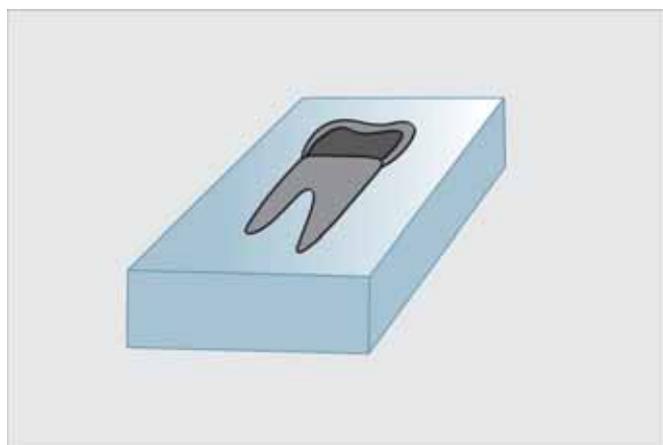


Fig. 7: Control (no treatment)

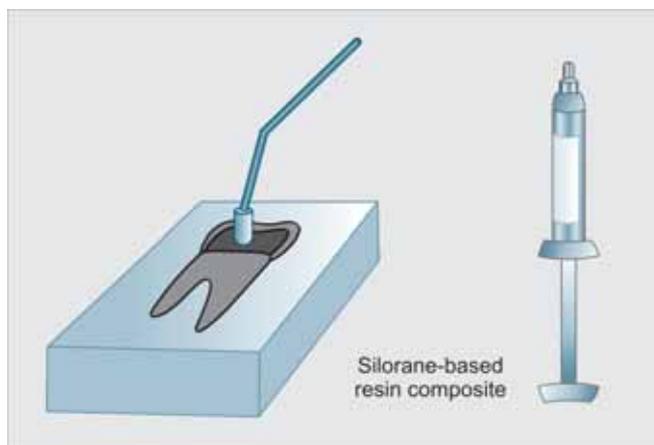


Fig. 9: Resin composite application

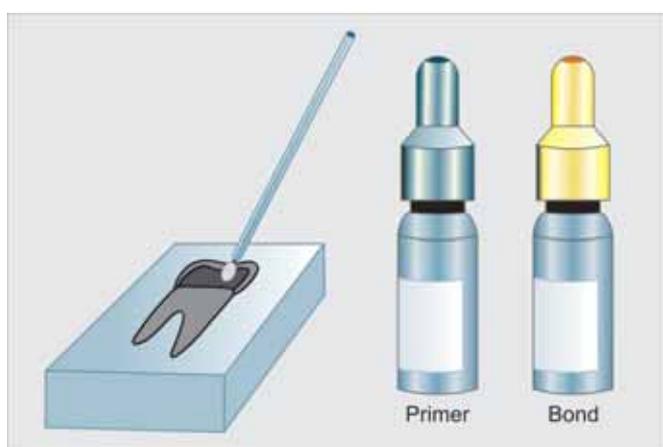


Fig. 8: Adhesive system application

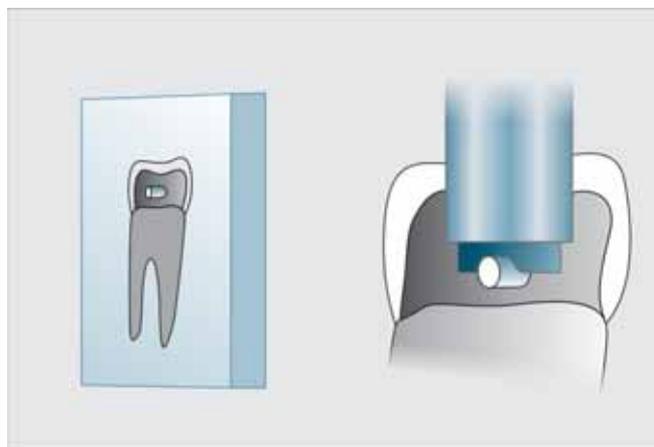


Fig. 10: Shear bond strength test

RESULTS

The mean shear bond strengths and standard deviations of the tested groups are shown in Table 2. One-way ANOVA revealed that the bond strength values were not statistically significant from each other ($p = 0.074$).

DISCUSSION

The use of disinfection agents may reduce or eliminate bacteria in cavity preparations and might increase the

success and longevity of restorations. On the other hand these agents might affect the bonding ability of resin materials to tooth substrate. Therefore the aim of this study was to compare different disinfection agents' effect on resin bond strength. In the present study, it was found that the cavity disinfectants CHX, NaOCl, propolis, ozone and Er:Cr:YSGG laser had no adverse effect on the shear bond strength of Filtek Silorane used with a self-etching adhesive system. Thus, the null hypothesis of the current study was accepted.

Table 1. Materials used in this study

Materials	Composition
Filtek Silorane 3M ESPE, St. Paul, MN, USA Batch# N1 22786	Bis-3,4-Epoxy cyclohexylethylphenylmethylsilane, 3,4-Epoxy cyclohexylcyclopolymethylsiloxane, Silanized, Quartz, Yttrium fluoride
Filtek Silorane Primer 3M ESPE, St. Paul, MN, USA Batch# 8BF	Phosphorylated methacrylates, Vitrebond copolymer, Bis-GMA, HEMA, Water, Ethanol, Silorane-treated silica filler
Filtek Silorane Adhesive 3M ESPE, St. Paul, MN, USA Batch# 8BB	Hydrophobic dimethacrylate, Phosphorylated methacrylates, TEGDMA, Silorane-treated silica filler

Bis-GMA: bis-phenol A diglycidylmethacrylate; HEMA: 2-hydroxyethyl methacrylate; TEGDMA: Triethylene glycol dimethacrylate

Table 2. Mean shear bond strengths to dentin in MPa and standard deviations; n= 12

Groups	Shear bond strength	Standard deviation (SD)
Group I (CHX)	13.76	1.31
Group II (NaOCl)	13.17	1.35
Group III (Propolis)	14.51	1.63
Group IV (Ozone)	14.07	1.35
Group V (Laser)	13.32	1.48
Group VI (Control)	14.55	1.67

CHX has been proven to be the most effective and safe disinfectant agent for many years.⁴ As it has a rewetting capacity and a strong affinity to tooth structure, it might have been expected that CHX would improve dentin bond strengths. The results of the present study, which shows no adverse effect on bond strength, are contrary to previous *in vitro* studies.^{2,27} According to a study of Ercan et al² the pretreatment of dentin surfaces with NaOCl, H₂O₂ or CHX solutions had a negative effect on the shear bond strength of self-etch adhesive systems. They suggested preferring an etch-and-rinse adhesive when NaOCl, H₂O₂ or chlorhexidine solutions are used as a cavity disinfectant. In the other study, while 0.12% and 2% CHX did not show any influence on the bond strength of etch-and-rinse adhesive systems, the application of 2% CHX was found to be deleterious to self-etch adhesive systems.²⁷ They recommended avoiding using CHX-based cavity disinfectants in concentrations higher than 0.12% prior to the self-etch adhesive system's application. Celik et al found that CHX's effect on bond strength might differ according to the type of the adhesive system used.²⁸ Ricci et al²⁹ evaluated the influence of CHX application on the immediate microtensile bond strength of three different two-step etch-and-rinse adhesive systems to the dentin of primary and permanent teeth. However, they applied CHX after acid etching. While CHX application increased the bond of Prime & Bond NT and Single Bond to the acid-etched dentin, no positive or negative effect was observed for Excite DSC. They concluded that the treatment of phosphoric acid-etched dentin with a 2% CHX solution did not affect negatively the bond strength of etch-and-rinse adhesive systems. Similar to our findings, Soares et al³⁰ also reported that the use of CHX before, after or associated with acid-etching did not significantly affect the bond strength values to dentin. Recently, the use of CHX in an aqueous solution or associated with the acid conditioner was found to be effective to reduce the degradation of dentin bonds over a 2-year period.³¹ However, in some studies, the CHX solution exerted an adverse effect on shear bond strength when used with a self-etch adhesive system.^{2,27}

Sodium hypochlorite has been used as one of the most common cavity disinfectants in clinical practice. Although

it has been proposed that the dentin substrate after deproteinization exhibits a remarkably porous structure with multiple irregularities, controversial still results about its' effect on bond strength.^{2,12} Most studies report the decreased bond strength values after NaOCl treatment.^{2,32,33} It has been claimed that remnants of superoxide radicals generated by NaOCl within the dentin surface inhibit polymerization of resin monomers. However in the present study, NaOCl had no adverse effect on bond strength when the self-etching system was used. This might be related with the adhesive systems' composition. On the other hand, rinsing the treated surfaces with water could remove the oxidized products from the dentin surface. In another study it was reported that the effects of NaOCl pretreatment on bonding of both self-etch adhesives were dependent upon type of dentin (normal and caries-affected dentin) and the treatment time.¹²

Propolis's antimicrobial efficacy has been shown in several studies.¹⁴⁻¹⁶ Many recent studies showed that a sub-inhibitory concentration of EEP was used to record its action on some important virulence factors like lipase and coagulase enzymes, and biofilm formation in *Staphylococcus aureus*³³ and mutant streptococci.^{34,35} Koo et al,³⁶ stated that mouthrinses containing propolis showed significant reduction of dental plaque compared to the placebo, and also significant inhibition of insoluble polysaccharide formation. In our study, propolis had no adverse effect on bond strength when used as a cavity disinfectant. To the extent of author's knowledge, no study has been conducted in the literature that evaluated the propolis's effect on bond strength.

Ozone is a promising alternative caries-management strategy, and has opened a wide range of potential treatment protocols. One of these therapeutic options could be the effective disinfection of cavities after conventional removal of caries, which may reduce the risk of residual caries formation and inflammation of the pulp due to remaining bacteria in dentinal tubules.³⁷ This strong oxidant has been shown to effectively kill up to 99.9% of bacteria present after an application period of only 20s.³⁸ The application of ozone with a concentration of 2,100 ppm for 80s on an *in vitro* infected dentinal cavity model has been reported to be successful in reducing the number of microorganism, thus confirming the potential of this treatment to disinfect carious cavities.³⁹ Ozone is also able to break up acidic products of cariogenic bacteria. The results of our study indicate that using ozone prior to the application of Filtek Silorane did not affect the bonding ability. Gürkan et al,⁴⁰ evaluated the effect of ozone and Nd:YAG laser pretreatment on bond strength of self-etch adhesives to coronal and root dentin. Similar to our study, they also found pretreatments with ozone did not impair the bond strength

of self-etch adhesives. In an *in vitro* study, the influence of direct high-dose gaseous ozone on dentin and enamel bond strength was evaluated. Despite possible retention of surface and subsurface oxide-related substances during high-dose ozone application, shear bond strength was not impaired.⁴¹ It was also found that the use of ozone gas to disinfect the cavity before placing a restoration had no influence on immediate enamel and dentin bond strength.⁴²

The disinfecting ability of different types of lasers has been studied from several aspects. In a recent study, the effect of two different cavity disinfection procedures; CHX-based cavity disinfectant and Er,Cr:YSGG laser irradiation was evaluated on the bond strength of an etch-and-rinse and self-etch adhesive.²⁷ While CHX and laser irradiation produced significantly higher bond strength values compared to the untreated group for etch-and-rinse adhesive, laser irradiation improved the bond strength for the self-etch adhesive. They concluded that as a cavity-disinfecting procedure, laser irradiation enhanced the bond strength of etch and rinse and self-etch adhesive systems. Siso et al⁴³ evaluated the microleakage of class V composite restorations after antimicrobial pretreatments; KTP laser irradiation, 2% CHX and Clearfil Protect Bond. While there were no significant differences between the groups on dentin margins, KTP laser irradiation exhibited the lowest microleakage scores on enamel margins. However, contradictory results have also been reported in the literature regarding the bonding effectiveness of adhesive systems to laser-irradiated dentin. While some studies demonstrated a decrease in bond strength values after laser irradiation,^{44,45} some found no difference.^{46,47} In an *in vitro* study, the dentin bond strength to resin composite following erbium:yttrium-aluminum-garnet (Er:YAG) laser preparation using different adhesive systems was evaluated. The results suggested that dentin surfaces prepared with an Er:YAG laser may provide comparable composite resin bond strengths depending on the adhesives used.⁴⁸ The diversity of these results might be related with the laser output, and also with the composition of adhesive systems used. It has been claimed that the dentine surfaces irradiated by the Er,Cr:YSGG laser showed a scaly and rugged appearance and open dentinal tubules without smear layer production.⁴⁹ On the other hand, lased dentin revealed an imbricate patterned substrate and the presence of microcracks at the dentin surface.⁴⁴ Our study showed that the use of a laser to disinfect the cavity before placing a restoration did not influence the bond strength.

According to the data we obtained, the bond strength values to dentin were very low. The self-etching primer of the Silorane System Adhesive has a pH of 2.7 and thus can

be classified as 'ultra-mild'. This might be related with the pH of this system. As the use of Filtek Silorane resin composite is increasing day by day because of its low shrinkage properties, these results should be supported with future clinical studies to determine whether the same results would be found *in vivo* as were found *in vitro* in the current study.

CONCLUSION

According to the limitations of the current study, it can be concluded that cavity disinfection with CHX, NaOCl, propolis, ozone, and laser did not significantly affect the bond strength of Filtek Silorane used with its' respective self-etch adhesive system.

CLINICAL SIGNIFICANCE

Cavity disinfectant applications did not affect the dentin bond strength of a silorane-based resin composite.

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