Effect of Surface Sealants on Marginal Microleakage in Class V Resin Composite Restorations

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ABSTRACT

Purpose: Surface sealants may reduce or avoid problems related to the marginal interface. The aim of this study was to evaluate the microleakage in resin composite Class V restorations sealed with an adhesive system (Xeno III [Dentsply, Konstanz, Germany]), a sealant for exposed dentin (Seal & Protect [Dentsply]), and two surface sealants (Fortify [Bisco, Lombard, IL, USA]; Optiguard [Kerr, Orange, CA, USA]).

Materials and Methods: Fifty cavities with margins in enamel were prepared on crowns of bovine teeth and restored with an adhesive system (Prime and Bond NT/Dentsply) and resin composite (Esthet X/Dentsply). They were separated into four groups for the application of the surface sealants, and a control group (without surface sealing). Thermal cycling with baths of 5°C ± 2°C and 55°C ± 2°C were performed in 600 cycles. The teeth were made impermeable, except for a 3-mm window around the restoration and immersed in a 50% silver nitrate solution for 8 hours. The crown was sectioned longitudinally and the cuts were analyzed by three independent evaluators, using a stereoscopic loupe with 10× magnification that attributed representative scores. Agreement among the examiners was evaluated by the Kappa test.

Results: The Kruskal–Wallis test and Dunn Method showed that there was significant difference between the Control and Seal & Protect groups. The Seal & Protect group presented the lowest degree of microleakage, followed by the Optiguard and Xeno III groups. The highest scores were obtained in the Control group.

Conclusion: The sealant materials evaluated presented different rates of effectiveness, and Seal & Protect was the most effective in decreasing the degree of marginal microleakage.

CLINICAL SIGNIFICANCE

Although surface sealants or covering agents have been used to diminish microleakage, they may present different rates of effectiveness with regard to reducing the degree of marginal leakage.

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INTRODUCTION

The mechanism of bonding esthetic restorations to the dental structure was introduced by Buonocore[1] when he observed that tooth enamel etched with phosphoric acid allowed efficient retention of acrylic resin on the enamel surface. From then on, studies were conducted in order to investigate the effects of acid etching on the dental structure.[2,3] Nowadays, bonding to enamel is a universally accepted process whose effectiveness has been proved. Nevertheless, the margins of a restoration are not always exclusively in enamel[4] and the effectiveness of acid etching in enamel lead to the same procedure being performed in a completely different substrate: dentin. This enabled the development of adhesive restorative systems and improvement in the characteristic of dentin bonding.[5,6]

From this aspect, light activated resin composites, which are routinely used as restorative materials in anterior and posterior teeth, also developed to a great extent because of the esthetic demands of patients and by reason of conservative cavity preparations. New formulations were researched to improve the physical and mechanical properties of resin composites.[7–9] Manufacturers have endeavored to make them more efficient, by introducing modifications in their composition, such as diminishing the particle size, increasing radiopacity, changing the shape and distribution of load particles, to improve their characteristics.[10,11]

However, resin composites still have undesirable properties, such as polymerization shrinkage that can generate failure at the restorative material/tooth interface, leading to microleakage, marginal discoloration, postoperative sensitivity, secondary caries, and pulp pathologies.[12,13] Various factors influence shrinkage stresses, such as cavity configuration, defined by Feilzer et al.[14] as factor-C (ratio between the free surface area and the adhered surface area in resin composite restorations) and the speed with which polymerization occurs, in addition to the modulus of elasticity and the contraction itself inherent to the resinous material.

In order to minimize the problems resulting from polymerization shrinkage, some procedures are recommended while making a restoration. Thus, the following are suggested: incremental resin composite insertion into the cavity,[15,16] the use of glass ionomer or resin-modified glass ionomer as a liner,[17,18] adequate polymerization—respecting the adequate time and energy density[14,19,20] and even the application of surface sealants.[21–24]

Surface sealants or covering agents were specifically developed for sealing restorations with resins.[25] They are light polymerizable materials which, because of the presence of components in their formulation, present greater fluidity and penetration capacity than materials such as fissure sealants and dental adhesives.[26] These materials have been used to diminish microleakage, because of their characteristic of fluidity, presenting the capacity to penetrate into micro gaps at the interface—especially at the dentin and cement margins and consequently promote a better marginal seal.[23] Furthermore, they can diminish the final roughness of the restoration and consequent plaque accumulation.

Therefore, it could be necessary to study the efficacy of surface sealing materials used to minimize marginal leakage in Class V cavities in resin composite.

MATERIALS AND METHODS

Fifty bovine teeth without cracks and fractures, stored in distilled water that was changed every day, were used for this experiment. They were cleaned to remove periodontal remnants and prophylaxis was performed. The roots were cut 5 mm from the amelocement limit. The pulp remainder was removed and the root orifice filled with autopolymerizing acrylic resin.

Fifty Class V cavities were prepared on the vestibular faces of the crowns of the teeth, with external margins in enamel. To determine the cavity width, a mold made of adhesive paper was used. This mold presented the shape of the rounded cavity outline, measuring 5-mm long and 2-mm wide, these dimensions being transferred to the tooth with a No. 2 black pencil. Using a flat-topped diamond tip with stop No. 2292 (KG Sorensen, Barueri, São Paulo, Brazil), a depth equivalent to 2 mm was obtained. After the cavities were prepared, 37% phosphoric acid was applied for 15 seconds. The cavities were washed for 20 seconds, and remained blotted after the application of a gentle jet of air. The adhesive system (Prime & Bond NT [Dentsply, Konstanz, Germany]) was passively applied, dried for 5 seconds, and light polymerized for 20 seconds with a medium light power of 478 mW/cm^2 (436–520 mW/cm^2) measured with a radiometer (Newdent, São Carlos, São Paulo, Brazil). A light polymerizable microhybrid resin (Esthet X/Dentsply—shade A2) was inserted into the cavities in two increments. The first increment was placed up to 1 mm of the complete extent of the cavity, and a second filled the remainder of the cavity. Each increment was light activated for 40 seconds, using the same light polymerizer appliance.

After making the restorations, the teeth were stored in distilled water at 37°C for 24 hours. The restorations were polished with abrasive paper disks in coarse, medium, fine, and extra fine grains in decreasing order of abrasiveness, removing excess material, and at the same time polishing the restoration surface. The teeth were randomly divided into five groups, materials were applied according to Table 1 in accordance with the manufacturers' instructions. A control group (G5) received no surface protection material.

To apply the sealants, a mold made of adhesive paper, measuring 7-mm long and 4-mm wide was used. For groups 1 to 4, acid-etching was performed on the restoration, using 37% phosphoric acid for 15 seconds. Acid removal was performed for 20 seconds, and drying with a light jet of air for 20 seconds. The surface sealants were applied in the following manner: **Group 1**—A thin layer of surface sealant Fortify (Bisco, Lombard, IL, USA) was applied and light polymerized for 10 seconds. **Group 2**—A thin layer of surface sealant Optiguard (Kerr, Orange, CA, USA) was applied and light polymerized for 20 seconds. **Group 3**—A thin layer of surface sealant Seal, Protect (Dentsply) was applied and light polymerized for 10 seconds. After that, a second layer of the material was applied and again light polymerized for 10 seconds. **Group 4**—The universal adhesive Xeno III was first mixed (component from flask 1 with that of flask 2) in order to compose a uniform liquid. Next, a layer was applied and light polymerized for 20 seconds. **Group 5**—No surface protection material was applied on the restoration.

After the sealants were applied, the cervical and incisal portions of these extremities were filled or sealed with chemically activated acrylic resin. Thermal cycling proceeded between baths, with a transfer time of 3 seconds between them. The teeth remained immersed for 1 minute in each water bath, totaling 600 cycles between 5 ± 2 and 55 ± 2°C. After thermal cycling, the coronal and apical extremities of the teeth were covered with two layers of instant adhesive (Superbonder-Loctite Henkel [Itapevi, São Paulo, Brazil]) and a layer of Araldite (Brascola Ltda, Joinville, Santa Catarina, Brazil) to ensure that there would be no dye leaking from these regions. The group to which the tooth belonged was identified by engraving the number on the palatine faces of the teeth in low relief, using a spherical burr No. 1013 (KG Sorensen). The teeth were completely dried and made completely impermeable with three layers of red nail varnish (Colorama-Maybelline), except for

TABLE 1. GROUPS AND SURFACE SEALANTS USED IN THE EXPERIMENT, MANUFACTURERS, LOT NUMBERS AND COMPOSITION.

Group	Brand	Material	Manufacturer	Lot	Composition
1	Fortify	Surface Sealant	Bisco	05000003609	Urethane Dimethacrylate Bisphenol A Ethoxylated dimethacrylate (BisEMA)
2	Optiguard	Surface Sealant	Kerr	409741	BIS-GMA, Deama-borum trifluoride, TEGDMA AND Photoinitiator
3	Seal & Protect	Protective sealant for exposed dentin	Dentsply	0502000279	Resins of trimethacrylate, amorphous silica, PENTA (single phase acrylic penta dipentaerythritol), Photoinitiators, Butylated hydroxytoluene, Cetylaminohydro-fluoride, Triclosan, Acetone
4	Xeno III	Universal / Self-etching Adhesive System	Dentsply	O504000522	**Liquid A** 2-hydroxyethyl methacrylate (HEMA), Purified water, Ethanol, Toluene hydroxybutyrate (THB), Amorphous Silica **Liquid B** Acid functionalized Methacrylate Phosphoric (Piro-EMA), Modified Monofluoride phosphazene (PEM-F), Urethane Dimethacrylate, THB, Camphorquinone Ethyl-4-dimethylaminobenzoate
5	Without Protection	—	—	—	—

a 3-mm window around the restoration margins, i.e., 8-mm long and 5-mm wide, to that 1 mm of the nail varnish was exposed to the dye. For this purpose, a mold made of adhesive paper covering the restoration was used. The teeth were immersed in a 50% silver nitrate solution for 8 hours in complete absence of light. After this period, the teeth were washed for 1 minute and dried with absorbent paper. Next, they were sectioned longitudinally in the center of the tooth in the incisal–apical direction, and in the vestibular–lingual direction using a cutting machine. The cuts were exposed to a special lamp (Photoflood, GE, Matoon, IL, USA) for 5 minutes to develop the silver nitrate. The cuts were identified and fixed on a slide with No.7 wax. The margins were analyzed separately using an optic microscope (Axioskope, Zeiss, Zena, Germany) with 10× magnification and the images obtained were transferred to a computer and digitized. Dye penetration was analyzed in accordance with the following criteria: **0** = absence of dye penetration; **1** = slight microleakage: dye penetration less than or equal to 1/3 of the extent of the tooth/restoration interface; **2** = moderate microleakage: dye

TABLE 2. QUALITATIVE EVALUATION OF INTEREXAMINER AGREEMENT AND THE RESULTS OF THE KAPPA AGREEMENT TEST.

Pairs of examiners	Kappa
1 × 2	1.0000
2 × 3	0.9301
1 × 3	0.9301

penetration greater than 1/3 of the extent and up to 1/2 of the extent of the tooth/restoration interface; and 3 = severe microleakage: dye penetration attaining over 1/2 the extent of the tooth/restoration interface. The digitized images of the two halves of the cuts were analyzed separately by three independent evaluators, on the same day, in the morning period, in the same room and under the same light and temperature conditions. The three evaluators were master's students in Dentistry and had knowledge of the methodology. The evaluators were instructed about the evaluation criteria, and guided to observe both cuts of each specimen, both under the loupe and the digitized image, previously fixed and positioned to record the highest degree of dye penetration at the tooth/restoration interface in the coronal and apical portions of each tooth. Agreement among the examiners was evaluated by Kappa by means of the SAS statistical program (Cary, NC, USA). Evaluation of the data was done by the Kruskal–Wallis nonparametric test, using the median of the evaluations made by the three examiners, using the Multiple Comparisons test for the individual verifications (Dunn Method). The statistical calculations were made by the software package Bioestat 4.0 (Belém, Pará, Brazil) with a level of significance of 5%.

RESULTS

Table 2 shows the values of the interexaminer agreement measures and the results of the Kappa agreement test.

One observes that agreement was considered "almost perfect" according to Landis and Koch.[27]

Table 3 shows the frequency in numbers and in percentages of the marginal leakage scores for the study groups and the results of the Dunn test.

Values followed by different letters differ among them by the Kruskal–Wallis and Dunn tests ($p < 0.05$).

Statistically significant difference was found among the tested groups, at a level of significance of 5%. One can observe that there was significant difference in microleakage only between the Control (without protection) and Seal & Protect groups and between the Fortify and Seal & Protect groups.

The Seal & Protect group presented the lowest degree of leakage, followed by the Optiguard and Xeno III groups. The groups Control and Fortify presented the highest microleakage scores.

DISCUSSION

Microleakage at the tooth/restoration interface is considered an important factor in the maintenance of dental restorations.[28] One finds that the goal of Adhesive Dentistry is to obtain canalicular and marginal sealing by the application of adhesive systems and resin composites. The use of surface sealants has been proposed to improve marginal sealing at the tooth/restoration interface, to minimize and even prevent marginal leakage.[29]

High marginal leaking values in composite restorations could be related to a high rate of polymerization stress associated with the cavity design—cavitary configuration factor or C factor—which is calculated from the ratio between the area of adhered surfaces and the area of nonadhered surfaces.[14] In this study, all the restorations were made in standardized cavity preparations (5-mm long and 2-mm wide) and therefore, the existent C factor was equal for all

TABLE 3. FREQUENCY OF MARGINAL LEAKAGE SCORES AS A FUNCTION OF THE GROUPS STUDIED AND THE RESULTS OF THE DUNN TEST.

Scores	Fortify		Optiguard		Seal & Protect		Xeno III		Without protection	
	n	%	n	%	n	%	n	%	n	%
0	2	20	4	40	10	100	6	60	1	10
1	8	80	5	50	0	0	4	40	7	70
2	0	0	0	0	0	0	0	0	1	10
3	0	0	1	10	0	0	0	0	1	10
Dunn	a		ab		b		ab		a	

Means followed by different letters differ among them by Kruskal–Wallis and Dunn tests ($p \leq 0.05$).

groups. Feilzer et al.[14] related that the C factor is around 1 to 2 in Class II preparations, and can attain over 5 in Class I preparations. In this study, Class V type cavities were prepared, which presented a high C factor (= 5) that increases the stress caused at the tooth/restoration interface during polymerization shrinkage of the composite, because the restoration-free surface is very small, when compared with the surface adhered to the cavity, which allows little composite flow during light polymerization. Moreover, one finds that the increments of resin in the cavity were made without concern about reducing the C factor in the cavity, as they were placed into the cavity in a horizontal manner, with bonding of opposite walls and greater polymerization shrinkage.[14]

In this study, bovine teeth were used as a result of the growing difficulty in obtaining human teeth, and also because they are an accepted type of substrate and are used in various experiments.[30]

Silver nitrate was used, as this is a very severe test,[31,32] because the diameter of the silver ion is very small (0.059 nm) when compared with the mean size of a bacteria (0.5–1.0 μm).[33] Therefore, if the adhesive prevents the penetration of silver nitrate in vitro, it would probably also prevent bacterial microleakage in vivo.

The association of dyes with thermal cycling is another procedure performed in microleakage tests. The goal of thermal cycling is to subject the tooth-restoration assembly to extreme temperatures, similar to those found in the oral cavity during ingestion of hot and cold foods.[34]

In this study, it was found that the groups treated with exposed dentin protector (Seal & Protect) presented the lowest degree of microleakage, followed by the groups treated with Optiguard surface sealant and universal adhesive Xeno III. The Control (without treatment) groups treated with Fortify surface sealant presented the highest microleakage scores. Although acid conditioning was performed on all restoration surfaces, including enamel and dentin margins, no effects may be related as only enamel margin was evaluated.

According to Kawai and Leinfelder,[26] the surface sealant is minimally resistant to abrasion or wear; therefore, only the sealant that penetrates into the restoration could increase the resistance to wear. According to Tjan and Tan,[35] the sealant film detaches in the course of time because of some incompatibility between the resin and sealant, probably because they are made by different manufacturers. According to this reasoning, the capacity to seal gaps could also be affected by this compatibility, because the group in which the exposed dentin protector was used was the one that presented the best result, this being from the same manufacturer as the resin used in the experiment.

Only the dentin protector Seal & Protect was capable of avoiding marginal microleakage at the tooth/restoration interface in all the samples. However, the lowest dye penetration index verified in the groups treated with Optiguard surface sealant leads one to believe that degradation of the composite margin by the action of saliva and/or bacterial plaque would be made more difficult.

Although the application of resins without load (surface sealants) has been recommended to reseal resin composite restorations, the best result was precisely that of a material that has load—the exposed dentin protector—surpassing the performance of surface sealants.

This result could also be a result of manufacturer's recommendation to apply two layers of the exposed dentin sealant Seal & Protect—differently from the other materials. Reid et al.[36] and Ramos et al.[24] affirmed that the degree of surface sealant penetration, and consequently, its effectiveness for improving marginal integrity would be dependant on its viscosity and ability to penetrate the etched interface. However, one can observe that the number of layers, as well as the resealing technique, could also interfere in the results. Veronezi et al.[23] showed that none of the surface sealants evaluated provided perfect marginal sealing; there was reduction in leakage, in spite of not being complete, in the same way as was observed in this study. This reduction was also found by Ramos et al.[24] and Myaki et al.[37] who concluded that the application of surface sealant promoted significant reduction in marginal leakage, increasing the longevity of the restoration.

In 2004, Lowe[29] described the reasons for the use of surface sealants, and clinical indications for these sealants, and recommended that these materials should be reapplied in subsequent visits, so that their efficacy should be evaluated both at the time of application and in the long term. However, the restoration could be subject to staining because some sealants presenting HEMA in their composition (hydrophilic monomer) would facilitate the incorporation of pigments.[25]

Based on the marginal microleakage findings in this experiment, one can infer that sealing resin composite restoration margins with exposed dentin protector Seal & Protect was effective in preserving the marginal sealing of the restoration. In spite of Ramos et al.[24] relating that the surface sealing technique is simple, increases marginal integrity and the useful life of the restoration, it could result in staining and surface roughness (presence of load), compromising the esthetic quality of the restoration at the same time in which it could facilitate bacterial plaque accumulation. Even so, it is recommended that further studies should be conducted with regard to the subject, in order to continue the search for materials and/or new techniques for minimizing microleakage in resin composite restorations.

CONCLUSIONS

According to the methodology used and the results obtained in this study, it may be concluded that:

1. The surface protection materials evaluated presented different rates of effectiveness with regard to reducing the degree of marginal leakage; and
2. Only the material Seal & Protect was shown to be effective for reducing the degree of marginal microleakage, when compared with the control group.

DISCLOSURE

The authors do not have any financial interest in the companies whose materials are discussed in this article.

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