Influence of Surface Sealants on Microleakage of Composite Resin Restorations

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ABSTRACT

Purpose: The purpose of this study was to verify the influence of surface sealants and dentin adhesive systems on the microleakage of composite restorations.
Methods: Class V cavities were made on the buccal faces of 100 permanent third molars and restored with Z250. After 24 hours, they were submitted to polishing and finishing processes. The teeth were divided into groups according to the sealant agent: group 1—Single Bond; group 2—Opti Bond Solo Plus; group 3—Fortify; group 4—Fortify Plus; and group 5—control without sealant. The analysis of immediate microleakage was performed in 10 restorations from each group, soon after the sealing. The other 10 specimens from each group were submitted to tooth-brushing and thermal cycles. The teeth were isolated and immersed in 2% methylene blue solution, washed in tap water, and sectioned in the buccolingual direction. The percentage of marginal leakage was calculated using an image analysis program, and results were submitted to analysis of variance and Tukey's test.
Results: All the sealed groups demonstrated lower microleakage values compared to the control group. Group 3, sealed with Fortify, presented the lowest mean microleakage values.
Conclusion: The application of surface sealants effectively decreased the microleakage in composite resin restorations. (J Dent Child 2008;75:24-8) Received January 8, 2007 | Last Revision April 4, 2007 | Revision Accepted April 20, 2007.

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Composite resins have been available to the dental profession since the beginning of the 1960s[1] and have since undergone changes in their composition—with the use of posterior resin composites increasing substantially over the last few years.[2]

Small defects are commonly found on the surfaces of composite restorations, particularly in stress-bearing areas.[3] These defects may be created by finishing processes extending across and below the surface,[4] thus increasing wear rates and the roughness of composite restorations. A rough surface may decrease the gloss and aesthetic appearance of the restoration[5] and facilitate the mechanical attachment of the dental plaque.[6]

Based on this information, it was hypothesized that a surface penetrating sealant could effectively refortify the composite resin,[7] filling the micro defects on its surface and increasing the wear resistance of composite restorations.

In addition, the surface penetrating sealant could decrease or impede the microleakage around the interface composite restoration/tooth. According to Ramos *et al*,[8] microleakage occurs due to microgap formation along the interface, which may be attributed to several factors:

1. the polymerization shrinkage that causes tensions in the tooth/restoration interface;

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2. marginal microcrack formation and, consequently, flaws in the adhesion of the material with the dental structure;
3. differences in the coefficient of thermal expansion between composite and tooth structure, not the incremental fill technique of composite insertion; and
4. the finishing and polishing procedures, because using rotating instruments can generate tensions in the interface, creating microfractures or microgaps.

Thus, the purpose of this study was to evaluate the effect of surface sealants on the marginal sealing of Class V composite resin restorations and to analyze the performance of the agents in preventing or reducing microleakage.

METHODS

The materials used in this study are shown in Table 1. One hundred sound, noncarious human permanent third molars extracted within a 6-month period were selected and cleaned with a scaler and pumice in a dental prophylactic cup. The teeth were stored in a 0.5% chloramine solution for 1 week and, afterwards, in distilled water at 4°C before the experimentations (ISO TR 11405). The teeth were embedded in Resapol polyethylene resin (Reichhold do Brasil, Mogi das Cruzes, São Paulo, Brazil), with the buccal face of the teeth exposed. Class V cavities were prepared on the buccal face of each tooth, with the occlusal margin in enamel and the cervical margin in cementum, using a no. 3145 bur at high speed with air/water spray. The dimensions of the preparation were 1.5 mm in depth, 3 mm mesiodistal, and 2 mm occlusal-gingival. The bur was changed after 5 preparations. The Research Ethics Committee of Piracicaba School of Dentistry, Campinas State University, Piracicaba, Brazil, approved the utilization of human teeth to this study (process no. 022/2002).

Each cavity was washed with water and etched using 35% phosphoric acid Scotchbond Etching Gel (3M, St. Paul, Minn) for 15 seconds, rinsed for 30 seconds, and gently dried with absorbent paper to keep the tooth surface moist. Two layers of Single Bond dentin adhesive (3M) were applied, and the last layer was photoactivated for 10 seconds using Curing Light 2500 (3M). The Z250 composite resin (3M) was bulk inserted in the cavities and photoactivated for 30 seconds. The output intensity of the visible light curing unit was 500mW/cm^2. After 24 hours, the finishing procedures were accomplished using the Sof-Lex system (3M) and the specimens were divided into 5 groups (N=20) according to the surface treatment.

Table 1. Materials Used in This Study

Material	Name	Manufacturer	Batch no.
Composite resin	Z250	3M ESPE (St. Paul, Minn)	1KE
Dentin adhesive without filler	Single Bond	3M ESPE	1GA
Dentin adhesive with filler	Opti Bond Solo Plus	Kerr Corporation (Orange, Calif)	107294
Surface penetrating sealant without filler	Fortify	Bisco (Schaumburg, Ill)	0000003216
Surface penetrating sealant with filler	Fortify Plus	Bisco	0200000444

In group 1, the surface and adjacent margins of the restorations (1 mm beyond the tooth/restoration interface) were etched with 35% phosphoric acid Scotchbond Etching Gel (3M) for 15 seconds, rinsed for 30 seconds, gently dried with compressed air, and then sealed with Single Bond dentin adhesive (3M), which was light cured for 10 seconds.

Group 2 received the same treatment as group 1 before sealing with Opti Bond Solo Plus dentin adhesive with filler (Kerr Corp, Orange, Calif) and light curing for 20 seconds.

Group 3 received the same treatment as group 1 before sealing with Fortify surface penetrating sealant (Bisco, Schaumburg, Ill) and light curing for 20 seconds.

Group 4 received the same treatment as group 1, before sealing with Fortify Plus surface penetrating sealant with filler burg (Bisco) and light curing for 10 seconds.

In group 5, the control group, the restorations did not receive any sealer agents.

Ten specimens from each group were submitted to 500 thermal cycles (5°C-55°C) using a MSCT–3 Plus thermal cycling machine (Marcelo Nucci, São Carlos, Brazil). In preparation for the dye penetration test, the specimens were dried superficially and 2 coats of Revlon nail varnish (Ceil, São Paulo, Brazil) were applied to the entire specimen surface, leaving a 1-mm window around the cavity margins. The samples were then immersed in a 2% methylene blue-buffered solution for 4 hours. Teeth were then washed in tap water and sectioned longitudinally in a buccolingual direction in an Isomet 1000 sectioning machine (Buheler, Lake Bluuf, USA), forming a 1-mm-thick slice from each tooth.

The slices were analyzed with a Leica stereoscope loupe (Carl Zeiss, Göttingen, Germany), and the images were digitized with a digital camera (model no. TK–C1380, JVC, Yokohama, Japan). The percentage of marginal leakage was calculated using a Leica Qwin Plus image analysis program (Leica Microsystems, Heerbrugg, Switzerland). To calculate the microleakage, the whole interface tooth-composite restoration was measured in the image analysis program (mm). After this, only the penetrated margin with tracer agent was measured. Three measurements were performed on each surface. The percentage of microleakage was then calculated:

$$\text{Percentage of microleakage} = \frac{\text{Penetrated margin x 100}}{\text{Hole interface}}$$

The calculation was performed on both sides of each slice, but only the side with the highest microleakage was considered in the results. The other 10 specimens from each group were not submitted to the thermocycling regimen. After the polishing procedures and group division, these samples were immediately isolated with nail varnish, immersed in the tracer agent, and sectioned with a diamond saw. The calculation of microleakage was immediately carried out in the same manner as previously described. Results were submitted to analysis of variance and Tukey's test (5%).

RESULTS

Independently of the time, the Fortify surface penetrating sealant demonstrated the lowest microleakage values, which were significantly different statistically to those of the control group (*P*=.028), as illustrated in Table 2.

Table 2. Marginal Microleakage Mean Values (%) Independent of the Time

Sealer agent	Microleakage %±(SD)*
Control	19.52±14.62 a
* Single Bond	14.73±9.40 a b
Fortify Plus	8.29±7.90 a b
* Opti Bond Solo Plus	7.34±4.61 a b
Fortify	4.84±2.56 b

** Means followed by distinct letters are statistically different (5%).*

Table 3 shows that, independent of the sealer agent used, the highest values of marginal leakage were obtained in delayed analysis, after the thermocycling procedure (*P*=.002).

Table 3. Marginal Microleakage Mean Values (%) Independent of the Sealer Agent

Time	Microleakage %±(SD)*
After the thermocycling procedure	15.41±10.64 a
* Immediately	6.48±5.01 b

** Means followed by distinct letter are statistically different (5%).*

Table 4 illustrates marginal microleakage values regarding the sealer agent used and the time analyzed. Results (columns) demonstrate that the control group presented higher values of marginal microleakage soon after thermocycling, with a statistically significant difference compared to the Fortify Plus (immediately) and Fortify groups (after thermocycling; *P*=.04). No statistically differences were observed among the other groups (*P*=.56).

Marginal microleakage values increased after the thermocycling procedure for all groups, although the differences were only statistically significant for the Single Bond and Fortify groups (*P*=.02).

DISCUSSION

Among the factors that determine the clinical longevity of restorations are the preservation of marginal sealing between the tooth and restorative material and the maintenance of the superficial integrity, which is responsible for the aesthetic qualities of the restoration. The first composite resins developed for clinical application demonstrated unsatisfactory properties, such as a high rate of wear,[9,10] Numerous dental research studies conducted more recently, however, have enabled the development of improved material properties. Currently available composite resins for posterior tooth restorations have physical characteristics that justify their use.[11]

*Table 4. Marginal Microleakage Mean Values According to Sealer Agent and Time (%)**

Sealer agent	Immediately after sealing±(SD)	After thermocycling±(SD)
*Control	13.17±9.38 A a	25.87±19.86 A a
Single Bond	6.72±4.95 A B a	22.75±13.86 A B b
Fortify Plus	2.23±2.92 B a	14.36±12.89 A B b
Opti Bond Solo Plus	6.94±4.59 A B a	7.73±4.64 A B a
Fortify	3.35±3.16 A B a	6.32±1.96 B a

** Means followed by distinct letters. Capital letters in a column and lower case letters in lines are statistically different (5%).*

The use of sealer agents on composite restorations has been proposed to improve the marginal sealing between tooth and restoration, thus avoiding or decreasing the marginal microleakage. Alani and Toh[12] reported that microleakage at the tooth/restoration interface is considered to be a major factor in influencing the longevity of dental restorations. According to Triadan,[13] there are 4 situations in which microleakage may present a serious clinical problem:

1. esthetics, particularly marginal discoloration;
2. sensitivity, frequently in Class 5 restorations;
3. percolation (ie, the pumping of saliva and bacteria through gaps in the periphery into the interior of a restored cavity); and
4. secondary marginal caries, which is considered to be the consequence of all periphery leaks.

The efficiency of sealer agents should be evaluated in recent and old restorations.

The use of the microleakage test in dentine, using tracer penetration, may have some disadvantages. According to Gale and Darvell,[14] even intact dentine tissue is permeable, possibly allowing the entry of the tracer into a tooth without passing it through a defective tooth-restoration interface. Despite efforts to use surface sealants, many thousands of open tubules adjacent to the margin often remain open. Alani and Toh,[12] however, reported that none of the methods available for the detection of microleakage are ideal. They also indicated that measurement of dye penetration by tracers is probably the most practical method, providing an acceptable degree of reliability.

All the groups showed some degree of marginal microleakage, Table 4. The surface penetrating sealant with filler (Fortify Plus) demonstrated the lowest immediate microleakage value (2%), followed by the Fortify surface penetrating sealant (3%), Single Bond dentin adhesive (7%), Opti Bond Solo Plus dentin adhesive with filler (7%), and the control group (13%). A statistically significant difference, however, was only observed for the Fortify Plus and control groups. The data obtained by the marginal leakage analysis should, therefore, be carefully interpreted. Although none of sealer agents were capable of impeding microleakage along the tooth/restoration interface, the decreased tracer penetration implies that the degradation of the composite margin by saliva and/or bacteria components is made more difficult by these materials. Triadan[13] stated that the formation of microfissures on the margin of an adhesive restoration does not necessarily have serious clinical consequences. Thus, the application of all the sealer agents tested efficiently decreased marginal microleakage compared with the control group. The best results, however, were obtained when the Fortify and Fortify Plus materials were used as surface sealants. According to Reid et al[15] and Tjan and Tan,[16] the success of the rebonding technique depends on the ability of the rebonding agent to adequately penetrate the debonded interface by a capillary action. Reid et al[15] and Ramos et al[17] reported that the degree of penetration of the surface sealant and, consequently, its effectiveness in increasing the marginal integrity, depends on the material's viscosity and the ability to wet the surfaces of the tooth and the composite resin restoration.

After the thermocycling procedures, the marginal microleakage values were higher than those of the immediate values (Table 3). Intragroup analysis revealed similar results. The difference in marginal microleakage was only statistically different, however, for the Single Bond and Fortify Plus sealants (Table 4). According to Alani and Toh,[12] thermocycling is defined as the in vitro process of subjecting a restoration and teeth to temperature extremes that conform to those found in the oral cavity. According to these results, we can conclude that the thermocycling procedure effectively simulated aging in restorations.

After the thermocycling procedure, the unsealed group demonstrated the highest marginal microleakage values (26%) compared to the other groups (Table 4). A statistically significant difference was only observed for the Fortify group (6%), which presented the lowest microleakage values. Again, care should be taken when interpreting these results. The most common pattern of restoration marginal microleakage occurred in the cervical margin. This phenomenon was also observed by Reid et al[15] and May Jr *et al*,[18] who showed very little leakage at enamel margins regardless of whether resin sealant was used. Thus, the marginal microleakage observed in the control group (26%) and the group sealed with Single Bond (23%), presented means of 70% to 80% tracer penetration in the cervical margin.

These results agree with those of Erhardt et al,[19] who related that using an unfilled resin to rebond dentin margins did not significantly reduce the microleakage for any of the systems used. This is because of the facility of this material to wear when exposed to thermal and abrasive oral conditions, consequently losing its effectiveness. Furthermore, Kemp-Scholte and Davidson[20] related that the high polymerization shrinkage of lower viscosity resin (up to 6%) might be expected to endanger the preservation of the bond. In a study by Munro et al,[21] only the group sealed with resin resin adhesive, without etching, presented statistically less dye penetration than the control group. According to these authors, the etcher may have opened more dentinal tubules than were sealed by the rebonding agent.

Reid et al[15] and Ramos et al[17] showed that the technique of rebonding with resin adhesive substantially reduced microleakage at the dentin and cementum margins of resin composite restorations. Torstenson et al[22] reported that the low-viscosity resin adhesive was able to flow between the gap resulting from the shrinkage polymerization of the resin composite, thus improving the restoration's marginal sealing.

The lowest marginal microleakage values were observed for the Fortify (6%), Opti Bond Solo Plus (8%), and Fortify Plus sealed groups (14%)—where the presence of filler in the composition did not impede marginal microleakage when compared with the Fortify-sealed group. Ramos et al[8] concluded that Fortify and Protect-it! presented better results than the control group in the cervical region. May Jr *et al*,[18] however, related that the application of the resin sealant (Fortify) significantly reduced leakage at the interface between VariGlass and dentin or cementum and that it is difficult to predict the clinical effectiveness of a surface sealant in reducing marginal microleakage.

Our study agrees with that of Ramos et al.[8] They concluded that the surface sealing technique is a simple one that enhances the interfacial integrity and increases the life of the restoration by employing a material with specific characteristics of wettability and viscosity that can penetrate the microcracks formed on the surface and along the interface of the restoration.

CONCLUSION

The application of surface sealants effectively decreased the microleakage in composite resin restorations.

REFERENCES

1. Bowen RL. Properties of a silica-reinforced polymer for dental restorations. J Am Dent Assoc 1963;66:57-64.
2. Suzuki S, Leinfelder KF, Hawai K, Tsuchitani Y. Effect of particle variation on wear rates of posterior composites. Am J Dent 1995;8:173-8.
3. Dickinson GL, Leinfelder KF. Assessing the long-term effect of a surface penetrating sealant. J Am Dent Assoc 1993;124:68-72.
4. Leinfelder KF. Using composite resin as a posterior restorative material. J Am Dent Assoc 1991;122:65-70.
5. O'Brien WJ, Johnston WM, Fanian F, Lambert S. The surface roughness and gloss of composites. J Dent Res 1984;63:685-8.
6. Leitão J, Hegdahl T. On the measuring of roughness. Acta Odontol Scand 1981;39:379-84.

7. Dickinson GL, Leinfelder KF, Mazer RB, Russell CM. Effect of surface penetrating sealant on wear rate of posterior composite resins. J Am Dent Assoc 1990;121:251-5.
8. Ramos RP, Chimello DT, Chinelatti MA, Dibb RGP, Mondelli J. Effect of three surface sealants on marginal sealing of Class V composite resin restorations. Oper Dent 2000;25:448-53.
9. Philips RW, Avery DR, Mehra R, Swartz ML, McCune RJ. Observations on a composite resin for Class II restorations: Two-year report. J Prosthet Dent 1972;28:164-9.
10. Heath JR, Wilson HJ. Abrasion of restorative materials by toothpaste. J Oral Rehabil 1976;3:121-38.
11. Christensen GJ. Amalgam vs composite resin: 1998. J Am Dent Assoc 1998;129:1757-9.
12. Alani AH, Toh CG. Detection of microleakage around dental restorations: A review. Oper Dent 1997;22:173-85.
13. Triadan H. When is microleakage a real clinical problem? Oper Dent 1987;12:153-7.
14. Gale MS, Darvell BW. Dentine permeability and tracer tests. J Dent 1999;27:1-11.
15. Reid JS, Saunders WP, Chen YY. The effect of bonding agent and fissure sealant on microleakage of composite resin restorations. Quintessence Int 1991;22:295-8.
16. Tjan AHL, Tan DE. Microleakage at gingival margins of Class V composite resin restorations rebonded with various low-viscosity resin systems. Quintessence Int 1991;22:565-73.
17. Ramos RP, Chinelatti MA, Chimello DT, Dibb RGP. Assessing microleakage in resin composite restorations rebonded with a surface sealant and three low-viscosity resin systems. Quintessence Int 2002;33:450-6.
18. May Jr KN, Swift Jr EJ, Wilder Jr AD, Futrell SC. Effect of surface sealant on microleakage of Class V restorations. Am J Dent 1996;9:133-6.
19. Erhardt MCG, Magalhães CS, Serra MC. The effect of rebonding on microleakage of Class V aesthetic restorations. Oper Dent 2002;27:396-402.
20. Kemp-Scholte CM, Davidson CL. Marginal sealing of curing contraction gaps in Class V composite resin restorations. J Dent Res 1988;67:841-5.
21. Munro GA, Hilton TJ, Hermesch CB. In vitro microleakage of etched and rebonded Class 5 composite resin restorations. Oper Dent 1996;21:203-8.
22. Torstenson B, Brännström M, Mattsson B. A new method for sealing composite resin contraction gaps in lined cavities. J Dent Res 1985;64:450-3.