Original Article

Microleakage Assessment of Class V Composite Restorations Rebonded with Three Different Methods

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ABSTRACT

Background: When composite resin polymerizes, shrinkage stresses tend to produce gaps at the tooth restoration interfaces. The aim of this study was to assess the ability of two low viscosity resin systems (Single Bond, and Prompt L-Pop) and a specific surface penetrating (PermaSeal) sealant in preventing microleakage in class V composite restorations.

Methods: Hundred and five caries free human premolars were selected. Wedge shaped cavities with occlusal margins in enamel and cervical margins in dentin were prepared and restored using Single Bond and Z100 composite resin. After storing the samples in distilled water for 24 hours, finishing and polishing was done and then they were randomly divided into six groups each including 15 samples along with one control group. Other groups were sealed using three different agents with and without etched margins. The specimens were thermocycled and then, immersed in a 50% silver nitrate solution as tracer agent for 4 hours. All samples sectioned longitudinally and analyzed for leakage (dye penetration) using a stereomicroscope. Kruskal-Wallis and Mann Whitney U tests were used for statistical analysis.

Results: Kruskal–Wallis test showed significant differences between the groups. Mann-Whitney U analysis revealed significant reduction in microleakage only in two groups namely, PermaSeal with etched and Prompt L-Pop without etched margins. There was no evidence of microleakage at the occlusal margins in any group.

Conclusion: The results obtained in this in vitro study showed that applying PermaSeal with etched and Prompt L-Pop without etched margins could reduce marginal leakage and improve marginal integrity.

Keywords: Composite resins, dental bonding, leakage.

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Introduction

Polymerization shrinkage of the resin materials is still considered highly responsible for the failure of direct resin composite restorations.[1] Polymerization shrinkage may induce stresses, which can lead to the breakdown of the bonding at cavity walls, promoting marginal gaps, and subsequent microleakage.[2] Microleakage may predispose a tooth to discoloration, recurrent caries, pulpal inflammation, post-operative sensitivity and worst of all, pulpal necrosis.[3] Many attempts have been made to prevent the occurrence of microleakage in tooth restoration interface, in order to maintain the integrity of restorations which gives rise to their longevity.[4] Incremental techniques, in vitro, can reduce the marginal contraction gaps by 25%.[5] Significantly, less leakage at restoration margins has been reported by using a glass ionomer base in sandwich technique.[6] Dentin bonding agents have been effective in reducing microleakage in gingival margins, but they could not eliminate it completely.[7-10] Unfortunately, all these approaches have failed to provide a satisfactory solution.[11,12] Most recently,

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several investigators have suggested painting a low–viscosity resin over the debonded tooth–composite resin interface to reseal the restoration margins, particularly at dentinal margins.[13] The concept of rebonding for sealing marginal gaps consists of applying an unfilled resin-bonding agent over the margins of the finished restorations. This compensates for the adverse effect of the polymerization shrinkage on the tooth-restoration interface and guarantees higher quality and durability of the marginal adaptation.[14-17] Penetration of the unfilled resin by capillary action would seal the marginal gaps, thus reduce microleakage.[16] Rebonding has been demonstrated in clinical studies to significantly reduce wear and prolong marginal integrity.[18] Based on the evidences collected from scanning electron micrographic interpretations, it is postulated that, though some rebonding resins could penetrate beyond 2 mm deep in the debonded interface, the wetting was incomplete. Poor wettability, improper fluidity of the rebonding agent and premature polymerization, as well as several other factors, including water or air entrapment, grinding debris, salivary contaminants, or surface roughness of the interfacial walls may be responsible for incomplete wetting. The adaptation quality of the rebonding resin to the cavity wall is important to eliminate microleakage. Because of the high polymerization shrinkage of unfilled rebonding resins, the rebonding technique could only be successful when implemented in conjunction with a composite resin with the lowest polymerization shrinkage, consequently producing minimal contraction gaps.[13] However, another misleading conclusion would be that one should use highly shrinking restoratives to create wider crevices, which can be filled more easily. If the crevices become too wide, a thick layer of sealant will be necessary. The large polymerization shrinkage of this layer will be hard to relieve by strain of the restoration.[19] Initially, there were attempts to use fissure sealants or bonding materials as covering agents.[5,17,20,21] Today, several commercial products with low-viscosity and high–flow rate such as Fortify (Bisco, USA), OptiGuard (Kerr, USA), Protect-It (Jeneric/Pentron, USA) and PermaSeal (Ultradent, USA) are available for rebonding. In a study, it was shown that rebonding of polymerized resin composite restoration optimized marginal sealing and lessened microleakage but acid etching the enamel margins before rebonding was not able to decrease microleakage compared to control group (without surface sealing) and proposed doing further studies to confirm or reject these suppositions.[22] On the other hand, the effectiveness of rebonding agent on reducing microleakage of class V aesthetic restorations has been rejected.[23] The aim of this study was to evaluate and compare the effectiveness of PermaSeal (Ultradent, USA), Single Bond (3M ESPE, USA) and Prompt L-Pop (3M ESPE, USA) in preventing microleakage at the margins of class V resin composite restorations.

Materials and Methods

One hundred and five caries-free human premolars were collected within 3 months and were stored in saline solution at room temperature. Using number 56 carbide burs at high speed and air/water spray with occlusal margins located in enamel and cervical margins in dentin, class V wedge shaped cavities with the following measurements were prepared: mesiodistal width, occlusogingival height and depth, which were 3 × 3 × 0.5 mm, respectively. The burs were replaced after five cavity preparations. A 45^{oC}, 1 mm bevel placed on the occlusal cavosurface using a flame-shaped diamond bur while cervical margin was kept at 90^{oC} with the external surface. The specimens were kept humid until the restorative procedures were carried out. First, the cavities were etched with a 37% phosphoric acid gel (3M ESPE, USA) for 30 seconds in enamel and 15 seconds in dentin and, then rinsed for 10 seconds and gently air dried for 5 seconds. Finally, the specimens were rewetted using cotton pellets, according to the wet bonding technique. Single Bond (3M ESPE, USA) was applied and air thinned for 5 seconds, a second layer of single bond was also used and light cured for 10 seconds with LED curing unit with a checked output of 500 mw/cm^2 (Top light, OMEGA LED curing light, spectrum range: 450 –490 nm). Z100 composite (3M ESPE, USA) A2 shade was inserted in 2 increments; each increment was cured for about 40 seconds and the second increment cured under pressure of Mylar strip. Then, the specimens were stored for 24 hours in distilled water at 37^{oC}. Finishing and polishing were accomplished using finishing carbide burs and Soflex disks from the coarse to fine, respectively. The samples were randomly divided into 7 groups each including 15 restorations as follows:

Group A: As control group, did not receive any surface sealing agents.
Group B: PermaSeal (Ultradent, USA) applied with microbrush over the restoration margins, gently thinned with brush and light cured for 20 seconds.
Group C: The surface and margins of the restoration (2 mm beyond the tooth/restoration interface) were etched using 37% phosphoric acid gel (3M ESPE, USA) for 10 seconds, rinsed for 10 seconds; gently, air dried for 5 seconds and then, PermaSeal was applied as in group B.
Group D: Single Bond (3M ESPE, USA) was applied with microbrush on the surface and margins of the restoration without etching and cured for 20 seconds.
Group E: Etching the margins was done as in group C and Single Bond was applied like group D.
Group F: Prompt L-Pop (3M ESPE, USA) was applied with microbrush on the surface and restoration margins and cured for 20 seconds.
Group G: Etching the margins was performed as in group C and Prompt L-Pop was applied like group F.

The specimens were submitted to a thermocycling regimen of 500 cycles between $5^{\circ C}$ and $55^{\circ C}$, with a 30 seconds dwell time in water bath. Due to dye penetration test, two coats of nail varnish were applied to the entire specimen surface, leaving a 2 mm window around the cavity margins. Foramen apices were sealed with sticky wax (Kem Dent, England). The specimens were immersed in 50% silver nitrate solution for 4 hours, then in processing solution (Champion, England) and were finally, exposed to fluorescent lamp for 8 hours. The teeth were embedded in blocks of a chemically activated acrylic resin (Meliodent, Bayer–Germany) and sectioned longitudinally in a buccolingual direction. The degree of marginal microleakage was determined by the tracer agent penetration, starting from the margins of the restoration towards the axial wall. The margins were analyzed by viewing under a stereomicroscope (N9 116434, wild MB, Germany) at a 28X magnification in a blind study with three examiners. The following criteria were used to score penetration of silver nitrate:

0 = Absence of dye penetration.
1 = Dye penetration up to half of the extension of cavity walls.
2 = Dye penetration to more than half of the extension of cavity walls without reaching the axial angle.
3 = Dye penetration into the whole extension of the walls and towards the pulp.

Kruskal Wallis and Mann Whitney U tests were used to statistically analyze the results at a significance level of 0.05.

Results

Observed scores in different groups are presented in table 1. In the occlusal margins, no evidence of microleakage in any of the groups was noted. Kruskal-Wallis analysis revealed that in the cervical region, there were statistically significant differences between test groups compared to the control group. Mann-Whitney U analysis showed significant difference between PermaSeal with acid etching ($P < 0.05$) and Prompt L-Pop without etching ($P < 0.002$) compared to the control group. In addition, etching was effective in reducing microleakage only in PermaSeal group ($P < 0.05$) and not in Single Bond and Prompt L-Pop.

Table 1. Distribution of microleakage scores in cervical margins (N = 15 per group).

Group	Category of microleakage				Sum
	0	1	2	3	
* Control	0	1	0	14	15
Single Bond (Etch -)	0	1	2	12	15
Single Bond (Etch +)	0	3	2	10	15
* P.L.P (Etch -)	0	5	5	5	15
P.L.P (Etch +)	0	4	1	10	15
PermaSeal (Etch -)	0	2	2	11	15
* PermaSeal (Etch +)	5	8	0	2	15

* $P < 0.05$

Discussion

May et al.[16] and Corona et al.[24] have stated that despite the constant development of dentin bonding adhesives, and application of glass ionomer hybrid materials and resin composites, the marginal sealing of cervical restorations still deserves considerable study. Gorracci et al.[25] showed that the degree of shrinkage, stiffness of the materials and the bond resistanceto tooth structure can predict the performance of material when microleakage is analyzed. Idriss et al.[26] and Ben Amar et al.[27] concluded that the choice of material and placement technique is important determining factors in microleakage. In this study there was no evidence of microleakage at the occlusal margins in any of the groups, proving the effectiveness of the acid etching technique in sealing restoration margins. This has been clearly shown in other studies too.[28-31] Torstenson et al.[20] reported that surface sealants should be applied before finishing and polishing. This is especially recommended because finishing may block the microgaps with debris and prevent the penetration of sealing agents into the finished composite. Torstenson and Oden[5] reported that any excessive heat generated during finishing and polishing may lead to breakdown of the covering agent applied on polymerized restoration and reopening of the gap. On the other hand, the finishing procedures could result in reopening of the marginal gaps due to the difference in the coefficient of thermal expansion between composite and tooth structures.[32] Similarly, others have also recommended placing the rebonding agent after finishing the restoration.[13,14] As resins undergo polymerization contraction on curing, Reid et al.[17] reported that the leakage could be secondary to surface sealant agents and resins. In addition, there may have been few unreacted methacrylate groups remaining on the surface of the composite to react with the surface sealant. Given that testing for leakage was done after only 24 hours of storage, gaps may also be present due to incomplete hygroscopic expansion of the composite.[17] The applied surface sealant agents in this study did not show similar results in reducing microleakage that are consistent with the results of other studies.[33-36] The best results emerged with PermaSeal with etching and Prompt L- Pop without etching. Single Bond however, showed the weakest results. Possible reasons for Single Bond failure could be attributed to technique sensitivity, the need for wet bonding technique (dentinal margins) and not uniform coverage of the entire interfacial surface.[34,35] Perdigao et al.[36] also believed that Single Bond includes polyalkenoic acid in its composition, which is associated with the formation of a thick resin layer with a low elasticity module of the hybrid layer; thus, viscosity and wetting for enough penetration into crevice remains incomplete. Prompt L-Pop showed significant difference in comparison to control group. One explanation may be that self–etching adhesives are less sensitive to water, but water is an essential component of such adhesive systems. Prompt L-Pop has phosphoric acid esters and water in a 4:1 ratio. The water may improve the Prompt L-Pop adhesive behavior. Another explanation is that the lower PH of Prompt L-Pop is sufficient to etch beyond the smear layer and demineralizes the underlying intact dentin with the formation of an authentic hybrid layer.[37] The bulk of the all-in-one adhesives consist of the solvents that are used to dissolve the resin components. They lack additional solvent free resin layers such as those utilized in three–step systems. Pashley et al.[38] showed that the low resin concentration and low viscosity of such adhesives could play an effective role in their penetration into gaps. In Prompt L-Pop dried, dull areas are often apparent on the smeared tooth surface, representing dry spots where the material is probably too thin for being successfully photo-polymerized. The dry spots may be responsible for the areas without the interfacial characteristics of hybridization under the SEM, and lower resin saturation in the upper half of the hybrid layer, which may be attributed to oxygen inhibition of the thin resin layer after water evaporation, preventing the adhesives from polymerizing.[39] Tay et al.[40] believed that acid etching before applying Prompt L-Pop may decline polymerization. The latter finding is in agreement with the results of our study. Although the need for etching prior to rebonding is somewhat controversial, it however proved effective in PermaSeal group. The purpose of etching prior to rebonding was to enhance resin adhesion and to remove any acid soluble substances that may have contaminated the restoration and adjacent tooth structures during restoration, finishing and polishing.[41] Due to low viscosity and high capillary properties, only PermaSeal could penetrate in marginal gaps. Although much detail is not given by the manufacturer about its composition, it is known that the surface sealants consist of a

Bis-GMA resin and the polymer was modified by adding low molecular weight monomers, consisting TEGDMA (Triethylene-glycol-dimethacrylat) and THFMA (Tetrahydrofuran-methacrylate); with the specific function of controlling viscosity and wetting characteristics, they show a potential for penetrating and filling microstructural defects as small as 1-2 mm.[42]

Shinkai et al.[43] found that the polymerization of the agent in the defects will lead the weakened surface to become more resistant to wear. The covering or rebonding agents offer a technique, which significantly enhance interfacial integrity, thus increasing the life of restorations. Using a material with specific wettability and viscosity, which can penetrate the microcracks, is strongly recommended by Munro, other wise, its application would be ineffective.[44] The longevity of a rebonding agent in the microgaps is unknown, but according to Dickinson and Leinfelder, its effectiveness could be enhanced if the material was reapplied biannually.[18]

Conclusion

The results obtained in this in vitro study showed that applying PermaSeal with etched and Prompt L-Pop without etched margins could reduce marginal leakage and improve marginal integrity.

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