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Original Article

The effect of re-bonding using surface sealant or adhesive system on microleakage of class V resin composite restorations

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ABSTRACT

Background: Microleakage is still one of the defects of resin composites that can lead to treatment failure; and re-bonding technique is one of the effective ways to reduce it. This study evaluated the effect of re-bonding with a surface sealant or a dentin adhesive on microleakage in class V microhybrid, nanohybrid, and packable composite restorations.
Materials and Methods: In this *in vitro* study, class V cavities with occlusal margins in enamel and cervical margins in dentin/cementum were prepared on the buccal and lingual surfaces of 54 extracted premolars. The prepared teeth were randomly assigned to three groups (3 group's × 18 teeth each), with each group being restored with microhybrid (Point 4); nanohybrid (Herculite XRV Ultra), and packable (Packable Premise) resin composite. Following finishing and polishing procedures, each group was randomly subdivided in to three subgroups ($n = 12$). The margins of two groups were both etched and re-bonded with surface sealant (Optiguard) or dentin adhesive (Opti Bond Solo Plus) and control group received no treatment. Specimens were thermocycled 1500 cycles, immersed in a methylene blue, sectioned, evaluated for microleakage using a stereomicroscope at a x 20 and scored on a scale of 0-3. Data were analyzed with Kruskal —Wallis, Mann —Whitney, and Wilcoxon tests ($\alpha = 0.05$).
Results: There were no significant differences among the three resin composites tested, and also no significant differences among subgroups with the same surface treatment. Only the microhybrid and packable composite restorations sealed with Optiguard had significantly lower microleakage compared to the control subgroups at the occlusal margin. There were no significant differences between occlusal and cervical margins regarding the microleakage scores when compared to the control subgroups of microhybrid and packable composite restorations.
Conclusion: The re-bonding technique could be considered as an advisable procedure in order to minimize microleakage and its effect might be material-dependent.

Key Words: Microleakage, re-bonding technique, resin composite, surface sealant

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INTRODUCTION

Resin composites have been widely used as a restorative material in dentistry because of the esthetic demands of patients. Due to their ability to bond to tooth structure, conservative cavity preparations can be completed.[1,2] Constantly, new formulations of resin composite are introduced with the aim of improving their physical and mechanical properties of resin composites. Means by which this is achieved includes diminishing the particle size, increasing radiopacity, changing the shape and distribution of load particles.[3] Nevertheless, resin composites still have limitations, such as microleakage associated with polymerization shrinkage, which is one of the most cited reasons for failure of resin composite restorations.[4-6] Therefore, the importance of a "perfect seal" for success and longevity of resin composite restorations has been well-documented.[7]

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The concept of re-bonding is one of several approaches to minimize a microleakage[8,9] by encouraging higher quality and durability of the marginal adaptation.[10] The re-bonding technique consists of applying a surface sealant or a dentin adhesive system over the margins of the finished restorations.[5,9,11] These materials penetrate to the structural micro-defects and marginal gaps by capillary action, thereby improving marginal sealing by reducing microleakage.[8-10] Clinical studies have demonstrated that re-bonding techniques significantly improve wear resistance[12,13] and prolong marginal integrity.[9,12]

Surface sealants are light polymerizable materials and contain Bisphenol-A Glycidyl Methacrylate (Bis-GMA), Urethane Dimethacrylate (UDMA), and Three Ethylene Glycol Dimethacrylate (TEGDMA) without filler particles,[1,9] which because of low viscosity and high wettability[1,9,14] penetrate into micro-gaps at the restoration interface and can minimize microleakage at dentin and cementum margins of resin composite restorations.[9] They can also reduce the surface roughness of the completed restoration and consequent plaque accumulation.[15,16] Moreover, *in vitro* studies have revealed that the application of adhesive systems as re-bonding agents minimize microleakage.[1,14,17]

Nowadays, in addition to dentin adhesive systems, several commercial products with low-viscosity and high flow rate such as Optiguard (Kerr Italia S.p.A., Salerno, Italy) are available for re-bonding techniques. These re-bonding agents exert their effects possibly with different efficacy on different resin composites.[1,8,9,11,18,19] Based on these considerations, the purpose of this *in vitro* study was to evaluate and to compare the effectiveness of a surface sealant (Optiguard, Kerr Italia S.p.A.) and an adhesive system (OptiBond Solo Plus, Kerr Italia S.p.A.) in preventing microleakage at the margins of class V microhybrid (Point 4, Kerr Italia S.p.A.); nanohybrid (Herculite XRV Ultra, Kerr Italia S.p.A.), and packable (Packable Premise, Kerr Italia S.p.A.) resin composite restorations.

MATERIALS AND METHODS

In this *in vitro* study, a total of 54 sound human maxillary premolars extracted for orthodontic reasons were collected and stored in saline solution at room temperature for less than 3 months. The teeth were scaled and cleaned with pumice; then stored in an aqueous buffered solution of formaldehyde (Yekta Chem Co., Tehran, Iran) for 2 h for infection control. Standardized box shaped class V cavities (3.0 mm in height, 3.0 mm in mesiodistal direction, and 1.5 mm in depth) were prepared on the buccal and lingual surfaces with a fissure diamond bur (Diatech Dental AG, Heerbrugg, Switzerland) mounted in a high-speed handpiece, under copious water spray. Each bur was replaced after 5 cavity preparations.

The occlusal margins were located 2 mm above the cementoenamel junction (CEJ) level in enamel and the cervical margins were located 1 mm apically to the CEJ level in dentin/cementum. A 1 mm, 45° bevel was placed on the occlusal margins using a flame-shaped diamond bur (Diatech Dental AG) although the cavosurface wall at cervical margin was finished to a butt joint. The teeth were kept humid during the study procedures.

The cavities were etched with a 37.5% phosphoric acid gel (Gel Etchant, Kerr Italia S.p.A., Salerno, Italy) for 15 s, then washed for 20 s and gently air dried for 5 s to remove excess moisture without desiccation of dentin. The adhesive system (OptiBond Solo Plus, Kerr Italia S.p.A.) was applied and dried for 5 s, a second layer of OptiBond Solo Plus was also used and light cured for 20 s with light-emitting diode (LED) curing unit (Coltolux LED, Coltene/Whaledent Inc., OH, USA) with a light intensity of 1000 mW/cm^2.

The teeth were randomly assigned into three groups (3 group's × 18 teeth):

Group A was restored with microhybrid resin composite (Point 4, Kerr Italia S.p.A.);

Group B was restored with nanohybrid resin composite (Herculite XRV Ultra, Kerr Italia S.p.A.);

Group C was restored with packable resin composite (Packable Premise, Kerr Italia S.p.A.).

Resin composite shade A2 was used for each group. These were placed in two increments; each increment was cured for 20 s according to manufacturers' instructions. The restorations were finished with finishing diamond burs (Diatech Dental AG) and polished with aluminum oxide discs (Kerr Hawe, Bioggio, Switzerland) under constant air/water coolant.

Each group was randomly divided into three subgroups (n = 12):

Subgroup I: The surface and margins of the restoration was etched using 37.5% phosphoric acid gel (Gel Etchant, Kerr Italia S.p.A.) for 10 s, rinsed for 20 s; gently air dried for 5 s. The surface sealant (Optiguard, Kerr Italia S.p.A.) was applied on the surface and margins of the restoration, and then gently thinned with a micro-brush and light cured (Coltolux LED, Coltene/Whaleden Inc) for 10 s according to the manufacturer's instructions.

Subgroup II: Etching was performed as described above, and the adhesive system (OptiBond Solo Plus, Kerr Italia S.p.A.) was applied and light cured as in subgroup I.

Subgroup III: As control subgroup, no acid etch and surface sealing agents were applied on the restoration.

The specimens were stored in distilled water at 37 ± 1°C for one month, thermocycled for 1500 cycles between 5°C and 55°C. The apices of the teeth were sealed with sticky wax. All the external surfaces of the teeth, except for a 1 mm margin around the restorations were covered with two layers of nail varnish. The teeth were then immersed in a 2% methylene blue solution (Merck KGaA, Darmstadt, Germany) for 24 h at room temperature. The specimens were rinsed under tap water, air dried. Afterwards, the teeth were sectioned into two halves mesiodistally in an occlusocervical direction through the middle of restoration with a water-cooled diamond disk (D&Z Diamant GmbH, Lemgo, Germany). Dye penetration was assessed in the two halves under a stereomicroscope (Nikon Eclips E600, Tokyo, Japan) at an ×20 magnification at the occlusal and cervical margins; if the microleakage score on the two halves was different, the half that showed more leakage was selected for assessment.

Two independent pre-calibrated investigators blindly scored all interfaces and the consensus was forced when disagreements occurred. Dye penetration was scored on a scale from 0 to 3: 0 = absence of dye penetration; 1 = dye penetration less than half of cavity wall; 2 = dye penetration more than half of cavity wall without reaching the axial wall; 3 = dye penetration spreading along the axial wall.[1,14,17,18,20] The microleakage scores were analyzed using the Kruskal — Wallis analysis of variance and Mann — Whitney *U* tests. The occlusal and cervical margins were compared with each other with Wilcoxon signed rank test at a significance level of 0.05.

RESULTS

The means and standard deviations of the microleakage scores in the experimental groups are presented in Table 1. Based on the results, none of the experimental groups were capable of completely eliminating marginal microleakage. The findings from the Kruskal — Wallis test showed that there were no statistically significant differences among the microhybrid, nanohybrid, and packable resin composite restorations in microleakage score. Furthermore, the same results were found from the inter-comparison of the counterpart subgroups.

The Mann — Whitney *U* test analysis revealed that only the microhybrid and packable composite restorations sealed with Optiguard ("sealant group") had significantly lower microleakage scores compared to the control subgroups at the occlusal margin ($P < 0.05$). Based on these results, nanohybrid resin composite sealed with Optiguard presented the lowest microleakage at the occlusal margins and the control subgroup (without surface sealing) of packable resin composite had the highest score at the cervical margins.

Table 1: Frequency, mean±SD of microleakage scores and *P* value of Wilcoxon signed rank test in the experimental groups on occlusal and cervical margins (*n*=12)

Group	Subgroup	Occlusal margins					Cervical margins					*P* value*
		0	1	2	3	Mean±SD	0	1	2	3	Mean±SD	
Microhybrid composite	OptiBond	8	2	2	0	0.50±0.80	5	3	3	1	1.00±1.04	0.014
	Optiguard	9	2	1	0	0.33±0.65	6	3	2	1	0.83±1.03	0.014
	Control	4	4	3	1	1.08±1.00	4	3	3	2	1.25±1.14	0.157‡
Nanohybrid composite	OptiBond	8	4	0	0	0.33±0.49	5	4	2	1	0.92±1.00	0.020
	Optiguard	9	3	0	0	0.25±0.45	5	5	1	1	0.83±0.94	0.020
	Control	5	5	2	0	0.75±0.75	4	4	3	1	1.08±1.00	0.046
Packable composite	OptiBond	8	3	1	0	0.42±0.67	5	4	1	2	1.00±1.13	0.020
	Optiguard	8	4	0	0	0.33±0.49	6	3	2	1	0.83±1.03	0.034
	Control	4	4	2	2	1.17±1.12	3	4	4	1	1.25±0.97	0.564‡

*Wilcoxon signed rank test; ‡Non-significant; SD: Standard deviation

The results of the Wilcoxon signed rank test demonstrated that there were no statistically significant differences between occlusal and cervical margins regarding the microleakage scores in control subgroups that were restored with microhybrid and packable resin composites, but these scores at the cervical margins were markedly higher than the occlusal margins in the others subgroups ($P < 0.05$).

DISCUSSION

Despite continuous improvement of adhesive systems, microleakage is still major concern in restorative dentistry and deserves considerable study. Good marginal sealing, via the use of appropriate adhesive systems and resin composites can help to minimize the microleakage and prolong the longevity of the restoration.[4,6,19] Ramos *et al*.[9] and dos Santos *et al*.[8] reported that the re-bonding technique may substantially minimize microleakage at margins of resin composite restorations, when a resin system with sufficiently low viscosity is used as a surface sealant, regardless of whether it has been specified for such a purpose. Furthermore, Mousavinasab *et al*.[14] concluded that applying PermaSeal with etched and Prompt L-Pop without etched margins could reduce marginal leakage and improve marginal integrity.

Based on these considerations, the present *in vitro* study evaluated the effectiveness of re-bonding on the marginal sealing ability of class V microhybrid (Point 4, Kerr Italia S.p.A.); nanohybrid (Herculite XRV Ultra, Kerr Italia S.p.A.) and packable (Packable Premise, Kerr Italia S.p.A.) resin composite restorations. In the current study, all of the sealed resin composite restorations exhibited different degrees microleakage at the bonded interface; this finding is in agreement with Silva Santana *et al*.[1] and D'Alpino *et al*.[16] who concluded that the evaluated surface sealants showed differing effectiveness in reducing microleakage; although, their effects were not absolute. In keeping with these studies, we demonstrated in the present study that the application of Optiguard surface sealant was significantly more effective than no treatment in enhancing the marginal sealing of the microhybrid and packable composite restorations at the occlusal margins of the assessed class V restorations; although, there were no significant differences among the nanohybrid subgroups. However, Ramos *et al*.[19] and Silva Santana *et al*.[1] showed that Optiguard surface sealant presented a similar result to the control subgroup (without sealing) on the marginal sealing of class V resin composite restorations. These discrepancies may be attributed to variations in resin composites and/or substrate and the different materials manufacturers. In another clinical study, Sakaguchi *et al*.[21] revealed that sealant, repair and refurbishing treatments improved the clinical properties of defective resin composite restorations by increasing the longevity of the restorations with minimal intervention.

According to the present findings, there were no significant differences in microleakage scores at the occlusal margins and cervical margins among the resin composite restorations tested that were re-bonded with OptiBond Solo Plus or with Optiguard or without protection (control). It seems that the bond strength between modern adhesive systems and etched enamel is adequate to reduce the microleakage of resin composite restorations. The residual water remained in the tooth/restoration interface is a predominant factor affecting resin penetration in to the gaps at the interface.[16] The same study showed that the resin composite restorations sealed with OptiBond Solo Plus had the lower microleakage values compared to the control group,[8] although, use of a dentin-bonding agent as a gap sealer demonstrated significantly better ability to prevent microleakage than did commercial products specifically designed for this purpose.[16]

Regarding to the effects of nanohybrid resin composite, our results demonstrated that the sealed and control subgroups of nanohybrid composite restorations presented the lowest degree of microleakage; although this effect was not significant. Herculite® XRV Ultra™, used in this study, is a nanohybrid resin composite containing submicron hybrid filler (0.4 microns) and nanoparticle filler (50 nm). It also has pre-polymerized filler particles (25 microns) containing the same submicron hybrid and nanoparticle fillers.[22] Moreover, the results verified that the nanohybrid resin composite sealed with Optiguard presented the lowest microleakage at the occlusal margins and the control subgroup (without surface sealing) of packable resin composite had the highest at the occlusal margins.

Significantly greater microleakage was revealed at the cervical margins compared to the occlusal margins of the material groups except for the control subgroups of microhybrid and packable composite restorations; also in this region, there were no statistically significant differences among the materials. This finding was in agreement with the similar studies.[9,14,17-19] This can be related to factors such as the composition of these two tissues and contraction stresses generated during the placement of a resin composite restoration.[23] In addition, the lower bond strength obtained in dentin is not strong enough to counteract the stress developed during the polymerization shrinkage which impairs the sealing capacity.[6]

Based on our findings, the first research hypothesis of this study, that the surface sealant would provide greater sealing ability than use of a dentin adhesive system was rejected, but the second hypothesis that surface sealant would demonstrate better marginal sealing compared to control subgroup (without protection), was proved in microhybrid and packable composite restorations. Although, the surface sealant and dentin adhesive system as re-bonding agent were not able to prevent marginal microleakge completely and its efficacy on reduction in microleakage might be material-dependent; the application of them are recommended to reseal the tested resin composite restorations. Further studies could investigate the effects of restorative materials or other techniques for reducing microleakage in resin composite restorations.

CONCLUSIONS

Although re-bonding techniques have been used to reduce microleakage, it is suggested that its efficacy on the amount of reduction might be material-dependent. Nevertheless, the application of the re-bonding agents including Optigard and OptiBond Solo Plus can be recommended to re-seal the tested resin composite restorations.

Within the limitations of the present study, it may be concluded that:

The OptiBond Solo Plus and Optiguard as re-bonding agent have different effectiveness and were not completely able to prevent the resin composites microleakage.

The application of re-bonding technique could be considered appropriate in order to reduce microleakage in resin composite restorations and this effect might be material-dependent.

The application of Optiguard on the microhybrid and packable composite restorations significantly provided better sealing than the control subgroup at the cervical margins.

The nanohybrid with and without re-bonding agent was shown the lowest degree of marginal microleakage; nevertheless, there were no significant differences when compared with the other groups.

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