

Effect of a Resin Coating Material on the Microleakage of Class V Restorations With or Without Post-Operative Bleaching

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Abstract

Objective: To evaluate the effect of a resin coating material on the microleakage of Class V composite resin restorations with and without post-operative bleaching. **Material and Methods:** Eighty class V cavities (3×3×1.5 mm) were prepared and filled with Z250 XT composite resin in the buccal and lingual surfaces of 40 sound human molars. Then the samples were randomly divided into 4 groups (n=20) and treated as follows: Group A: applying a resin coating (G-Coat Plus) on the restoration, then bleaching with 40% hydrogen peroxide; Group B: Post-Operative bleaching without prior use of resin coating; Group C: applying resin coating agent, and no further bleaching; and Group D: no resin coating, no bleaching. The specimens were thermocycled and immersed in 1% methylene blue for 24 hours, then cut into sections bucco-lingually. The samples were scored regarding the amount of dye penetration under a stereomicroscope (x20). Data were analyzed with Chi-squared and Fisher exact tests (p<0.05). **Results:** The maximum gingival and occlusal microleakage was detected in group B, while the minimum was seen in group C. In all the groups, microleakage at gingival margins was higher than occlusal margins (p<0.001). **Conclusion:** Application of a resin coating is an effective method in reducing microleakage of the restorations before and after bleaching.

Keywords: Dental Materials; Composite Resins; Hydrogen Peroxide; Dental Leakage.

Introduction

In current dentistry, composite resins are widely used due to improved mechanical properties, good aesthetic properties and strong bonding to the tooth structure. However, some of the limitations of their function, such as stress polymerization shrinkage and the resultant microleakage, are still a major concern. Creation of microleakage at marginal areas will pave the way for secondary caries, enamel cracks, staining of restoration and post-operative sensitivity [1].

In addition to these kinds of restorations, bleaching of discoloured teeth is becoming a common and popular treatment in dentistry as this approach is the most conservative and favorable procedure to improve the aesthetic appearance of teeth compared to other techniques [2]. For more durable results, bleaching of the vital teeth is usually carried out using the office bleaching followed by home bleaching techniques. Office bleaching entails the application of 35–38% hydrogen peroxide on the tooth surface for 30–45 minutes; and the home bleaching is usually carried out with the use of 10–20% carbamide peroxide in prefabricated special trays, which are worn by the patients at nights [3].

Several studies have reported that the microleakage at the dentin margins of Class V resin composite restorations following exposure to home bleaching agents would increase [4–6]. This increase in microleakage can potentially lead to a series of clinical problems, including bacterial accumulation, staining and pulp damage [7]. However, other studies that have showed that bleaching of teeth with 35% hydrogen peroxide and 10% carbamide peroxide does not have any effect on microleakage of class V tooth-coloured restorations [8–10]. Although there is no consensus on the effect of bleaching agents on the tooth-coloured restorative materials, replacement of the restoration after tooth bleaching is often advised due to poor post-treatment colour match and the degraded properties of the restorative material [7], which itself might have detrimental effects on remaining tooth structure and pulp vitality.

Recently, resin coatings have been considered to decrease discoloration and improve marginal integrity [3]. Studies have shown that the coating material exhibits a strong bond to enamel, dentin, composite, glass ionomer and resin-modified glass ionomer; thus, it can improve the marginal sealing between the tooth and the restorative material, prevents restoration discolorations, increases resistance to abrasion and results in a maturation effect in glass-ionomer restorations [7,11]. The protective effects of resin varnish against bleaching agents have been demonstrated by several studies [7,12,13]. Overall, resin coating is considered to be beneficial in reducing marginal staining and enhancing marginal integrity. Furthermore, it could potentially reduce the effect of bleaching agents on the microleakage of tooth-coloured restorative materials [7]. However, roughly little information is available to prove the efficacy of these new resin coating agents. Therefore, the present study aimed to evaluate the effect of a coating agent on the microleakage of class V composite resin restorations before and after bleaching with 40% hydrogen peroxide.

Therefore, two null hypotheses were proposed for the present study: 1) applying resin coating agent does not have any effect on marginal microleakage of resin composite restorations; and 2) applying resin coating agent has no effect on the marginal microleakage of composite resin restorations with post-operative bleaching.

Material and Methods

Study Design

The present in vitro study was carried out on 40 sound extracted human third molar teeth with no caries, cracks and restorations. The teeth were stored in 0.2% thymol solution (T0501, Sigma-Aldrich, Inc., San Luis, MO, USA) for disinfection for 48 hours after cleaning and removing the soft tissues.

Laboratory Procedures

Class V cavities, measuring 3×3×1.5 mm (the mesiodistal width = 3 mm, the occluso-gingival height = 3 mm, and the pulpal depth = 1.5 mm) were prepared on the buccal and lingual surfaces of the teeth with the use of a 0.08 diamond fissure bur (Diamont GmbH, D&Z, Berlin, Germany). The gingival margins of all the cavities were placed 1 mm below the CEJ (cemento-enamel junction). A periodontal probe was used to measure the cavity dimensions. Each bur was replaced with a new one after every five-cavity preparation procedures.

The cavities' enamel margins were etched with 35% phosphoric acid (Scotchbond Etchant Gel, 3M ESPE, St. Paul, MN, USA) for 15 seconds, rinsed for 5 seconds, and dried with a mild stream of air for 5 seconds, according to the manufacturer's instructions. Care was taken not to desiccate the dentin surface. In the next stage, G-Premio adhesive agent (GC Corporation, Tokyo, Japan) was applied on the enamel and dentin walls according to the manufacturer's instructions as follows: after a waiting interval of 10 seconds, a strong stream of air was applied on the adhesive with an air syringe. Finally, the adhesive was light-cured for 10 seconds. Then Z250 composite resin (3M ESPE, St. Paul, MN, USA) was placed in the cavity in layers with the thicknesses of ≤ 2-mm using the oblique incremental technique, and each layer was light-cured for 20 seconds. An LED light-curing unit (Starlight Pro, Mectron S.p.A, Genoa, Italy) was used for the light-curing procedure with a light intensity of 1000 mW/mm². After light-curing four samples, the light-curing unit's output light intensity was tested with a radiometer (Starlight Pro, Mectron S.p.A, Genoa, Italy). In the next stage, the restorations were polished with coarse, medium and soft polishing disks (Soflex, 3M ESPE, St. Paul, MN, USA).

The samples then were randomly assigned to four groups (n=20 in each group): Group A: applying resin coating agent on the restoration, post-operative bleaching; Group B: no resin coating, post-operative bleaching; Group C: applying resin coating, no bleaching; and Group D: no resin coating, no bleaching. Each cavity was given a specific code. The samples in groups A and C were dried with a mild stream of dry air. Then a layer of G-Coat Plus (GC Corporation, Tokyo, Japan) resin was applied over the restorations according to the manufacturer's instructions, followed by light-curing for 20 seconds.

The Bleaching Process

Before the bleaching procedure, each tooth was coated with two layers of nail varnish up to 1 mm away from the restorative margins. In groups A and B, the bleaching procedure was carried out in three rounds according to the manufacturer's instructions. In each round, 40% hydrogen peroxide gel (Opalescent, Ultradent Products Inc., South Jordan, UT, USA) was applied on the restoration surface for 15 minutes. The samples were irrigated and rinsed with copious water and a brush between the bleaching rounds (to provide the surfaces of the samples with fresh bleaching gel in next rounds). Finally, the samples were rinsed with water and immersed in normal saline solution. The samples that did not undergo a bleaching procedure (groups C and D) were immersed in normal saline solution all the time. All the samples underwent a thermocycling procedure for aging at 5/55°C for 30 seconds, which comprised 1000 cycles with a resting time of 10 seconds in a thermocycler (TC-300, Vafaei Industrial, Tehran, Iran). Table 1 presents the proprietary names, the manufacturers and the chemical structures of the materials being used.

Table 1. Composition, manufactures and materials.

| Composition | Manufacturer | Material |
|---|-------------------------|-------------------------------------|
| 10-MDP, 4-MET, MEPS, phosphoric acid ester monomer, dimethacrylate, acetone, silicon dioxide, initiators. pH=1.5 | GC Corp. | G-Premio |
| TEGMA, BIS-EMA, UDMA, BIS-GMA, PEGDMA, silica fillers/zirconia fillers (3 µm), non-agglomerated/non-aggregated (20 nm), filler loading 82% by weight, 68% by volume | 3M ESPE | Z250 XT Composite |
| 40% hydrogen peroxide, thickener, pigment, vegetable extracts, amide, sequestering agent, glycol and purified water. pH=6.5-7.5 | Ultradent Products Inc. | Opalescence (40% Hydrogen Peroxide) |
| 35% phosphoric acid solution | Ultradent Products Inc. | Etchant Gel |
| Methylmethacrylate, multifunctional methacrylate, and camphorquinone | GC Corp. | G Coat Plus |

10-MDP: 10-Methacryloyloxydecyl dihydrogen phosphate; 4-MET: 4-methacryloyloxyethyl trimellitic acid; MEPS: methacryloyloxyalkyl thiophosphate; TEGDMA: Triethylene glycol dimethacrylate; BIS-EMA: bisphenol A diglycidyl methacrylate ethoxylated; UDMA: urethane di-methacrylate; BIS-GMA: bisphenol A-glycidyl methacrylate; PEGDMA: Polyethylene glycol dimethacrylate.

Dye Penetration

Inlay wax was used for the apical seal of all the samples because it has minimum dimensional changes. All the tooth surfaces were covered with two layers of nail varnish except for a 1-mm rim around the restorations. Then, the tooth samples were immersed in 1% methylene blue in closed containers for 24 hours. After rinsing the samples under running water, each tooth was sectioned at the center of each restoration in a buccolingual direction, using a diamond disk (T201A Mecantome, Presi France, Eybens, France) by a cutting machine (Presi France, Eybens, France). The extent of dye penetration at occlusal and gingival margins was evaluated under a stereomicroscope (Model SZF-AL, Kyowa Electronic Instruments Co. Ltd., Tokyo, Japan) at a magnification of $\times 20$ and reported as follows: Score 0: No dye penetration; Score 1: Dye penetration up to 1/3 of the cavity depth; Score 2: Dye penetration up to 2/3 of the cavity depth; Score 3: Dye penetration up to the cavity floor; and Score 4: Involvement of the axial surface.

Data Analysis

Data were analyzed with SPSS 16 (SPSS AG, Schneckmannstrasse, Zürich). Qualitative data were analyzed with Chi-square and Fisher exact test and a 5% level of significance.

Ethical Considerations

This research protocol was approved by the Ethics Committee of the Faculty of Dentistry, Zanjan University of Medical Sciences (Ethical code: IR.ZUMS.REC.1397.07).

Results

Microleakage scores are presented in Tables 2 and 3. Microleakage increased at both the occlusal and gingival margins after bleaching ($p < 0.001$). The occlusal microleakage was statistically different between groups (A, B) ($p < 0/001$), groups (A, D) ($p < 0/001$), groups (B, C) ($p = 0.0035$), groups (C, D) ($p < 0.001$). The maximum and minimum gingival margin microleakage scores were reported in group B (score = 3) and group C (score = 0).

The gingival microleakage showed considerable differences between groups (A, B) ($p < 0.001$), groups (A, D) ($p < 0.001$), groups (B, C) ($p < 0.001$), groups (C, D) ($p < 0.001$). In all the groups, there was more microleakage at the gingival margins compared to the occlusal margins. The difference in microleakage of occlusal and gingival margins in each group was noticeable in group D ($p < 0.001$) and group B ($p < 0.001$).

Table 2. Distribution of microleakage at the occlusal margin.

| Groups | Scores | | | | | Total N (%) | p-value |
|--------|------------|------------|------------|------------|------------|----------------|---------|
| | 0 N (%) | 1 N (%) | 2 N (%) | 3 N (%) | 4 N (%) | | |
| A | 17 (85.0) | 3 (15.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 20 (100.0) | <0.05 |
| B | 2 (10.0) | 14 (70.0) | 1 (5.0) | 3 (15.0) | 0 (0.0) | 20 (100.0) | |
| C | 14 (70.0) | 5 (25.0) | 1 (5.0) | 0 (0.0) | 0 (0.0) | 20 (100.0) | |
| D | 7 (35.0) | 3 (15.0) | 4 (20.0) | 6 (30.0) | 0 (0.0) | 20 (100.0) | |

Table 3. Distribution of microleakage at the gingival margin.

| Groups | Scores | | | | | Total N (%) | p-value |
|--------|------------|------------|------------|------------|------------|----------------|---------|
| | 0 N (%) | 1 N (%) | 2 N (%) | 3 N (%) | 4 N (%) | | |
| A | 17 (85.0) | 0 (0.0) | 1 (5.0) | 2 (10.0) | 0 (0.0) | 20 (100.0) | <0.001 |
| B | 0 (0.0) | 1 (5.0) | 5 (25.0) | 14 (70.0) | 0 (0.0) | 20 (100.0) | |
| C | 17 (85.0) | 1 (5.0) | 0 (0.0) | 2 (10.0) | 0 (0.0) | 20 (100.0) | |
| D | 3 (15.0) | 3 (15.0) | 4 (20.0) | 10 (50.0) | 0 (0.0) | 20 (100.0) | |

Discussion

The present study aimed to evaluate the effect of a resin coating agent on the microleakage of Class V composite resin restorations with and without post-operative bleaching by 40% hydrogen peroxide. Based on the results of this study, the highest microleakage scores of the occlusal and gingival margins were observed in groups B (bleaching without prior application of resin coating agent), D (control group), A (applying resin coating and bleaching) and C (resin coating with no post-operative bleaching), respectively. Therefore, both null hypothesis of this study were rejected.

The bleaching mechanism relies on the reaction of free radicals resulting from the disintegration of hydrogen peroxide with the pigmented carbon macromolecules [14]. The bleaching agents can penetrate the restoration margins with a proper seal or through the restorative material's porosities, resulting in microleakage [3]. Furthermore, adsorption of salivary proteins to the surface of composite resin that has been subjected to a bleaching procedure might decrease, affecting the adhesion of cariogenic bacteria, such as *S. sabrinus* and *S. mutans*, to these surfaces [15]. According to previous studies, bleaching results in changes in composite resins characteristics, including changes in color, surface roughness and hardness, microleakage, and susceptibility to discoloration [6,16].

Consistent with the results of the present study, previous authors showed that bleaching resulted in a decrease in hardness and an increase in surface roughness and microleakage of hybrid composite resins [6]. It was reported that at-home and in-office bleaching affected the surface of class V adhesive resin restorations and resulted in marginal microleakage through some changes [16]. In addition, the effect of carbamide peroxide bleaching gel on microleakage depended on the type of restorative material being used. In the latter study, of all the composite resins being evaluated (Z100®, Z250® and Nulite F®) Nulite F® exhibited the maximum microleakage. In addition, an increase was observed in microleakage of the gingival margins of Z250® composite resin [5]. Bleaching with 30% hydrogen peroxide increased the microleakage of silorane-based composite resins significantly at the gingival margins compared to methacrylate-based composite resins [3].

On the other hand, previous authors showed that the bleaching agents had no effect on microleakage of enamel- and dentin-adhesive agent interface [8-10,17-19], which is in contrasts with the results of the present study. Some of the possible reasons for this might be the differences in the type of bonding agents

being used, not using a coating agent in these studies and the class of the cavity being prepared (Class 1), which was placed on the occlusal surface only, while in the present study, class V cavities were prepared with their gingival margin 1 mm below the CEJ.

Based on the results of the current study, the use of the coating agent significantly decreased the microleakage at both the occlusal and gingival margins in groups A and C, in which it was used. Coating agents can be cured with high-curing units and create a smooth, shiny and durable surface, preventing the discoloration of the restorative materials. An ideal marginal seal and protection of the tooth and the restoration margin are other advantages of these agents [11]. The surface coating is an effective technique to prevent bleaching-related microleakage of glass-ionomer cements [7]. Likewise, a previous study showed that unfilled and nanofilled surface sealants were the most effective method in decreasing the degree of marginal microleakage at dentin margins [20]. Other researchers have shown that surface sealants were effective in reducing marginal leakage degrees [21]. The results obtained by other researchers are also in line with the results of the present study showing that applying a resin coating agent prior to bleaching with carbamide peroxide dramatically decreased the microleakage at margins [22].

Conversely, the use of G-Coat Plus coating agent to coating the surfaces of class V cavities restored with Gradia Direct Flow® composite resin, which had immediately been polished, had no effect on decreasing the microleakage of the occlusal margins of the cavities [23]. Some of the reasons for the discrepancies between the study above and the present study might be differences in the type of the bonding agents, the composite resins and the bleaching techniques being used.

In the present study, G-Premio universal bonding agent was used. Based on previous studies, this bonding agent has a favorable bond strength irrespective of the etching techniques. It prevents post-operative hypersensitivity due to proper penetration and wettability and low viscosity [24,25].

In this study, the microleakage at the gingival margins was higher than that at the occlusal margin, which was consistent with the results of other studies. Some researchers concluded that after evaluating the adhesion of multimode adhesives, microleakage at gingival margins was higher than at occlusal margins [26]. It was previously shown that Scotch Bond universal adhesive has a performance similar to that of Adper Single Bond® 2 and Clearfil SE® Bond; however, its microleakage at the gingival margins of CI V cavities was higher compared to occlusal margins [25]. Also, another study revealed that the microleakage of CI V composite resin restorations with the use of self-etch universal adhesives in the self-etch mode at the occlusal margins was less than that with the total-etch mode, and in both modes, the microleakage at gingival margins was higher than that at the occlusal margins [27].

In the present study, intra-group comparisons of the samples in the occlusal and gingival regions showed significant differences in microleakage in groups B and D. In addition, the microleakage at the gingival margins was significantly higher than that at the occlusal margins. Given the mineral content of the enamel (approximately 89 vol%) and its completely different structure from dentin, there is a much stronger and reliable bond between the enamel and composite resin compared to the bond between the dentin and the resin restoration [14]. Such a stronger bond can explain the minimal effect of hydrogen peroxide gel on the microleakage of occlusal margins.

In this context, some researchers achieved similar results and reported that if carbamide peroxide is applied on nanohybrid composite resin with dentin margins, it would be better to consider replacing the restorations after bleaching. This situation applies to enamel margins at a lower rate [14]. A previous study showed that in the restoration of class V cavities filled by Opallis® composite resin and Embrace Wetbond®

resin sealant, the microleakage was higher in the second group and in both groups, microleakage at the gingival margins was higher compared to the occlusal margins [28]. In addition, different preparation techniques of class V cavities did not affect microleakage and in all the groups, microleakage at the gingival margins was higher than the occlusal margins [29].

Conclusion

Bleaching with hydrogen peroxide significantly increased the microleakage rate at the gingival and occlusal margins. Resin coating agents can have a positive effect on decreasing marginal microleakage with / without post-operative bleaching. Although in vitro studies provides less reliable evidence than in vivo studies, these microleakage studies can be used as a part of an in vitro pre-assessment of new materials. However, further clinical studies should be performed to determine the longevity of sealing ability of this material.

Authors' Contributions

| | | |
|----|---|--|
| SH |  0000-0003-0732-0077 | Methodology and Investigation. |
| EZ |  0000-0003-1489-1388 | Conceptualization, Methodology, Formal Analysis, Writing – Original Draft Preparation, Writing – Review and Editing and Supervision. |
| AN |  0000-0002-5691-0826 | Writing – Review and Editing and Supervision. |

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Conflict of Interest

The authors declare no conflicts of interest.

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