**Original Article**

# Effect of 30% Hydrogen Peroxide on Marginal Integrity of Silorane-Based Versus Methacrylate-Based Composite Restorations

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**Abstract**
**Objectives:** The aim of this study was to assess the effect of 30% hydrogen peroxide on the microleakage of class V cavities restored with either a silorane-based composite or two methacrylate-based composites.
**Materials and Methods:** A total of 96 standard class V cavities (1.5 × 2 × 3 mm) were prepared on the buccal surface of sound extracted human premolars with both enamel and dentin margins and randomly assigned into three groups of Filtek P90 (group A) with its respective bonding (P90 system adhesive), Filtek Z250 (group B) and Filtek Z350XT (group C), both with Adper Prompt L-Pop bonding. The teeth were subjected to thermocycling (1000×, 5–55ºC) and half of them randomly underwent bleaching (30% hydrogen peroxide, 15 min, three times), while the remaining half (control) were not bleached. Dye penetration was measured following immersion in 2% basic fuchsin for 24 h. Data were statistically analyzed using Kruskal-Wallis and Mann-Whitney U tests at 95% CI.
**Results:** No significant differences were found between the composites in the control groups in enamel (P=0.171) or dentin (P=0.094) margins. After bleaching, microleakage of Z250 (at the occlusal (P=0.696) or gingival (P=0.867) margins), Z350 (at the occlusal (P=0.323) margin) and P90 (at the occlusal (P=0.316) or gingival (P=0.281) margins) did not change significantly.
**Conclusion:** No significant differences were noted between the bleached and control subgroups of Z250 and P90 in enamel or dentin margins. Microleakage of Z350 composite was reduced at the gingival margin compared to the control group, but no significant difference was observed at the occlusal margin. Microleakage of silorane-based composite in gingival margin was significantly more than two metacrylate-based composites.
**Key Words:** Bleaching Agent; Dental Leakage; Silorane Resin

## INTRODUCTION
Tooth-colored restorations especially composite resins are now part of contemporary dentistry [1,2]. However, drawbacks such as polymerization shrinkage have compromised their clinical success.

Polymerization shrinkage will cause gap and subsequent microleakage [2].

The gap at the tooth-restoration interface allows passage of fluids, bacteria and ions leading to the development of complications including hypersensitivity, pulpal irritation and marginal discoloration [3,4]. Deceleration of polymerization rate [5], replacement of dual-cured composites with self-cured resins [6], applying a thicker adhesive coat below the composite resin [7] and application of the incremental technique [8] may help reduce the polymerization shrinkage and the resulting stresses. Changing the resin matrix and production of composite resins with small polymerization shrinkage such as silorane-based composites is a recently proposed technique to reduce polymerization shrinkage [2]. These composites undergo cationic ring-opening polymerization [2,4]. New monomers are produced by the reaction of Oxirane and Siloxane molecules and the name "Silorane" is derived from the names of these two molecules [2,3]. The manufacturer claims that this composite resin has two main advantages: the first is its small polymerization shrinkage due to the Oxirane ring opening mechanism and the second is its increased hydrophobicity attributed to the presence of Siloxane [4].

Studies have demonstrated that Silorane-based composites have similar or even more favorable mechanical and physical characteristics compared to methacrylate-based composites including a polymerization shrinkage of less than 1.5% [9,10], low water sorption [11], optimal biocompatibility [12], suitable color stability [13] and a good marginal fit [14 ,15] are among the favorable characteristics reported for this composite resin.

Bleaching is an effective and relatively safe esthetic treatment [16,17].

The bleaching agent usually contains peroxide (such as hydrogen peroxide, carbamide peroxide, and sodium perborate) [16,18] and it is usually applied through the office- or home-bleaching techniques [19] .

Office bleaching is usually carried out with the use of 35-38% hydrogen peroxide applied to the tooth surface for 30-45 minutes.

This process may be activated by light. Home bleaching is usually done with the application of carbamide peroxide delivered in a special tray customized for the patient, which is usually used at night [16]. Some researchers have investigated the effect of bleaching agents on physicochemical characteristics of tooth structure [20] and some others have evaluated the influence of bleaching materials on the properties of methacrylate-based composite resins [21] such as the elution of methacrylate monomers [18], their surface hardness and roughness [19], color [22] and microleakage [17].

The impact of whitening agents on some characteristics of Silorane-based composite resins namely their surface roughness and hardness [16] and enamel-dentin bond strength [23] has been evaluated in the literature as well. A group of researchers believe that tooth whitening agents are able to penetrate into the tooth structure through the unsealed dentin margin at the tooth-restoration interface [24] and thus, are capable of causing complications like tooth hypersensitivity and microleakage [17]. However, to date, no study has evaluated the effect of bleaching agents on the microleakage of cavities restored with Silorane-based composite resins.

Therefore, the present study sought to assess the effect of an office-bleaching agent on the microleakage of class V cavities restored with Silorane-based composite resins in comparison with two methacrylate-based composites (microhybrid and nanofilled).

The null hypothesis: The effect of bleaching with 38% carbamide peroxide on the microleakage of silorane-based and methacrylate-based composite restorations is the same.

## MATERIALS AND METHODS

The name of the used products, their composition and their manufacturing companies are summarized in Table 1.

### *Specimen preparation*

A total of 96 sound maxillary and mandibular premolar teeth that had been recently extracted as part of an orthodontic treatment plan and were free from carious lesions, cracks, fracture, or restorations were selected.

**Table 1.** Materials and Their Composition

| Type | Material | Content | Manufacturer |
|---|---|---|---|
| **Dash** | 30% Hydrogen peroxide | Hydrogen peroxide | Discus Dental, 8550 Higuera St, Culver City,USA |
| **FiltekZ250** | Microhybrid methacrylate-based composite | Bis-GMA, Bis-EMA,UDMA. TEGDMA Filler: zirconia, Silica, 78% thgiew percent 60% emulov percent elcitraP size 0.01-3.5 µm | 3M-ESPE. St.Paul, MN, USA |
| **Filtek Z350** | Nanofilled methacrylate-based composite | Bis-GMA, UDMA, Bis-EMA, Silica, zirconia, nanoparticles(20 $\mu m$ ),and nanoagglomerated (0.4-0.6 $\mu m$ ) | 3M-ESPE. St. Paul MN, USA |
| **Filtek P90** | Silorane-based Composite (microhybrid) | **Matrix**: 3,4 Epoxycyclohexyl ethyl cyclopolymethylsiloxane, bis-3,4 epoxycyclohexyl-ethyl-phenyl-methylsilane **Filler**: Silanized, quartz, Yttrium fluoride 76% tnecrep thgiew– 55% tnecrep emulov elcitraP size 0.04-1.7µm | 3M-ESPE, St. Paul MN.USA |
| **P90 System Adhesive** | Two step self-etch | **Primer**: phosphorylated-methacrylated, vitrebond copolymer Bis-GMA,HEMA , water, ethanol, Silane-treated silica filler, camphorquinone stabilizer **Bond**: hydrophobic dimethacrylate, phosphorylated-methacrylated ,TEGDMA , Silane-treated silica Filler, initiator, stabilizer | 3M-ESPE, St. Paul MN, USA |
| **Adper Prompt L-Pop** | Self-etch adhesive | Phosphate methacrylate, water, ethanol, Silanized Colloidal silica , Photo initiator | 3M-ESPE, St. Paul MN, USA |

The teeth were cleaned from blood and tissue appendages and immersed in 0.5% chloramine T solution at 4°C for one week according to ISO 11405 (ISO/TS 11405: 2003 (E), Dental materials-testing of adhesion to tooth structure) standards [25]. Then the teeth were polished with a rotary bristle brush and pumice paste and kept in distilled water to use for the experiment within the next 3 months [25]. Standard class V cavities measuring 3 mm (mesiodistal) x 2 mm (occlusogingival) x 1.5 mm (depth) were prepared by a diamond 008 fissure bur and high-speed hand piece with water spray on the buccal surface of all teeth with a gingival margin expansion 1 mm below the cementoenamel junction. The bur was changed for each five samples.

*Material application*
The teeth were randomly assigned into three groups as follows:
A.FiltekZ250 + Prompt L-Pop
B.FiltekZ350 + Prompt L-Pop
C.FiltekP90 + P90 adhesive
For group A, Prompt L-Pop was mixed according to the manufacturer's instructions and the entire surface of the cavity was coated with the bonding agent using a microbrush and rubbed for 15 s. After gentle air drying for 5 s and thinning of the adhesive coat, the entire surface was coated with the second layer of adhesive. After gentle air drying for 10 s, the adhesive layer was cured with the LED light curing unit (Valo, Ultradent, Products Inc, South Jordan USA) with 1000 mW/cm$^2$ intensity. Z250 was incrementally applied to the cavity obliquely in three layers. The first layer of composite resin was applied to the occlusal margin and occlusal one-third of the axial wall, the second layer was applied to the middle one-third of the axial wall and the third layer to the gingival margin and gingival one-third of the axial wall [26]. Each layer was photo cured for 10s.
Group B specimens were prepared according to the same protocol used for the previous

group. Group C specimens were prepared according to the manufacturer's instructions as follows: the entire surface of the cavity was coated with primer using a microbrush and rubbed for 15 s, followed by gentle air drying and light curing with an LED light-curing unit with 1000 mW/cm$^2$ intensity for 10s. Using another microbrush, the entire surface of the cavity was evenly soaked with the bonding agent, followed by gentle air drying and light curing for 10 s. The cavities were restored with P90 composite resin with the same technique described earlier. The specimens were finished and polished using Soflex aluminum oxide finishing and polishing discs (coarse, medium, fine, super fine) (3M-ESPE) and post-cured for another 20 s. The teeth were then immersed in distilled water and stored in an incubator at 37°C for 24 h.

*Thermocycling*
Specimens were subjected to thermocycling (TC 300, Vafaie Industrial, Iran Product) for 1000 cycles between 5°C and 55°C (±2°C ), with a 30s dwell time and a 10 s transfer time and then stored in distilled water and placed in an incubator at 37°C.

*Bleaching process*
Each group was randomly divided into two subgroups of 16 each (A1, A2, B1, B2, C1, C2). A1, B1 and C1 were immersed in distilled water at 37°C as the control groups and did not undergo the bleaching process. The teeth in A2, B2 and C2 groups were prepared for bleaching as follows: the teeth were first dried and separately fixed on a piece of dental wax on a smooth surface. According to the manufacturer's instructions, the bleaching process was performed for 15 min and repeated 3 times. In the first step, the surface of the samples was covered with whitening accelerator and then the whitening gel was applied to the same sides of the tooth. The samples were then rinsed with water and stored in distilled water in an incubator at 37°C.

## *Dye penetration*

The apex, root and furcation area were sealed by a layer of adhesive wax. All tooth surfaces were sealed with two layers of nail polish except for the restored area and 1mm around it. The specimens were then immersed in 2% fuchsin solution and stored in an incubator at 37°C for 24 h. The teeth were then washed and dried with sterile gauze and air spray and each group was separately mounted in a special mold using clear polyester resin (Taban, Iran). They were longitudinally sectioned by a cutting machine with 0.82 mm sectioning blade thickness (Mecatome, T201A, Presi, Grenoble, France) to produce two sections. Gingival and occlusal margin microleakage was assessed under a stereomicroscope (SMZ 800, Nikon, Japan) with 40X magnification and scored as below:

0: No dye penetration

1: Dye penetration extending up to ½ of the gingival/occlusal wall

2: Dye penetration extending to more than ½ of the gingival/occlusal wall

3: Dye penetration extending into the axial wall and pulp

## *Statistical analysis*

The Kruskal-Wallis tset was used to compare the three composites. If it was significant, Mann Whitney U test with Boneferroni adjustment was used for comparisons of the two. Mann-Whitney U test was used for the comparison of bleached and control subgroups as well. $P<0.05$ was considered statistically significant.

## RESULTS

Microleakage scores are demonstrated in Table 2. Kruskal-Wallis test showed no significant differences in microleakage at the occlusal ($P=0.171$) or gingival ($P=0.094$) margins between the three control groups of Z250, Z350 and P90 composite resins. After application of 30% hydrogen peroxide, no significant differences were observed in the microleakage of Z250 composite at the occlusal ($P=0.867$) or gingival ($P=0.59$) margins compared to the control group. In addition, microleakage of Z350 composite was reduced at the gingival margin ($P=0.019$) compared to the control group, but no significant difference was observed at the occlusal margin ($P=0.323$).

**Table 2.** Number of samples showing each microleakage score at both occlusal and gingival margins in the control and bleached groups

| Microleakage Scores* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Control** | | | | | **Bleached** | | | | | **P- value\*\*** |
| **Occlusal** | **0** | **1** | **2** | **3** | **Occlusal** | **0** | **1** | **2** | **3** | |
| FiltekZ250 [a] | 8 | 7 | 1 | 0 | FiltekZ250 [a] | 6 | 10 | 0 | 0 | **P**: 0.696 |
| FiltekZ350 [a] | 3 | 11 | 1 | 1 | FiltekZ350 [a] | 5 | 11 | 0 | 0 | **P**: 0.323 |
| FiltekP90 [a] | 4 | 10 | 1 | 0 | FiltekP90 [a] | 6 | 7 | 0 | 0 | **P**: 0.316 |
| **Gingival** | | | | | **Gingival** | | | | | |
| FiltekZ250 [d] | 11 | 3 | 1 | 1 | FiltekZ250 [d] | 11 | 5 | 0 | 0 | **P**: 0.867 |
| FiltekZ350 [d] | 0 | 10 | 0 | 1 | FiltekZ350 [d] | 11 | 5 | 0 | 0 | **P**: 0.019 |
| FiltekP90 [e] | 8 | 6 | 0 | 1 | FiltekP90 [e] | 4 | 12 | 0 | 0 | **P**: 0.281 |

*Same superscript letters in each column show no statistical significant differences between groups. e > d, ($P<0.05$ was considered statistically significant.)

** The given P-values are for comparison of control and bleached groups.

No significant differences were found in the microleakage of P90 composite at the occlusal (P=0.316) or gingival (P=0.281) margins compared to the control group.

Mann-Whitney U test showed no significant difference between the Z250 and Z350 composite resins (P=1) in the gingival margins, but the microleakage of P90 groups was significantly higher than Z250 (P=0.035) and Z350 (P=0.035) composite resins. After application of 30% hydrogen peroxide, no significant differences were noted in the microleakage between the occlusal and gingival margins of P90 (P=0.414), but the microleakage of the Z250 (P=0.025) and Z350 (P=0.014) at the occlusal margin were significantly greater than the gingival margin.

## DISCUSSION

We failed to find any significant difference in the microleakage between the control subgroups of P90 and the two methacrylate-based composites. Palin et al. [27] demonstrated that the microleakage of a Class V cavity restored with a silorane-based composite was not significantly different than that of a similar cavity restored with a methacrylate-based composite. On the other hand, Yamazak [28] and Al-Boni [29] reported less microleakage in P90 compared to methacrylate-based composites.

Hydrogen peroxide is capable of diffusion and penetration into the intact enamel and dentin structure [17]. Bleaching agents may pass through the unsealed restoration margins or porosities of restorations [24]. In our study, after bleaching with 30% H2O2 for 45 min, microleakage at the enamel margin in the three composites and gingival margins of methacrylate-based composites was not significantly different and bleaching did not cause a significant change in the microleakage in any group compared to the control group, except for the gingival margin of Z350.

These results are similar to those of Khoroushi [17] and Klukawaska [30] and in contrast to those of Moosavi et al. [31].

For Silorane-based composites, we did not find any similar study to compare our results. In our study, following bleaching with 30% H2O2, although the microleakage scores were ≤ 1 and were not significantly different to the control group, microleakage at the gingival margin of P90 was significantly greater than Z250 and Z350. Therefore, the null hypothesis was rejected. The mineral content of dentinal margins of a cavity is less than that of enamel margins. Furthermore, dentinal margins contain more moisture, which is responsible for greater microleakage [3].The greater microleakage of P90 at the gingival margin may be explained by the characteristics of the adhesive system in silorane-based composites. P90 primer has a pH of 2.7 that causes mild etching and slight demineralization of tooth structure and a strong durable bond [2]. This adhesive system was designed to bridge the gap between the hydrophilic dentin and the hydrophobic silorane-based composite. P90 bonding agents are offered in two separate bottles. Each part is photo-cured separately; whereas, in self-etch two-step adhesives, primer and bonding agents are mixed on the dentin surface and are photo-cured simultaneously [2]. This filled two-layer adhesive forms a thick layer on the tooth structure that may increase the strain capacity of the restoration [32] and consequently yields results similar or superior to those of methacrylate-based composites. Although according to the manufacturer's claim, a slight demineralization of tooth structure happens due to the low pH of P90 primer (2.7) [2], the result of this study did not show a favorable marginal integrity after the bleaching of P90. On the other hand, since the primer and adhesive of Prompt-L Pop (PLP) are being applied all at one step, the infiltration of the adhesive may be equal to the depth of demineralization that has been created by primer despite the low pH [26]. The authors of the present article think that is probably why microleakage of restorations that have been bond with PLP did not change the following bleach-

ing. It has been claimed that P90 primer forms a chemical bond with hydroxyapatite crystals, and this has recently been confirmed [33].

It has been documented that optimal bond stability is achievable in silorane-based adhesives.

However, there have been concerns regarding the quality and long-term stability of the P90 adhesive hybrid layer [34]. Santini et al. have observed an intermediate zone with 1 micrometer thickness between the primer and the silorane bond using Micro Raman spectroscopy. The authors of the mentioned study believe that this area might be the weakest zone of silorane adhesives that causes failure in restorations and therefore, further investigations are required in this respect [35].

Considering the claims regarding the presence of chemical bond [33] and one micrometer intermediate zone [35], it appears that the destructive effects of free radicals released by hydrogen peroxide led to the increased microleakage in silorane-based composite resin in the present study. However, the authors recommend further investigations to evaluate the degradation process of silorane-based composite.

## CONCLUSION

Under the conditions of this study, no significant differences were noted between the bleached and control subgroups of Z250 and P90 in enamel or dentin margins. Microleakage of Z350 composite was reduced at the gingival margin compared to the control group, but no significant difference was observed at the occlusal margin. Microleakage of silorane-based composite in the gingival margin was significantly higher than the two metacrylate-based composites.

## ACKNOWLEDGMENTS

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