



Comparison of Microleakage of Composite Restorations using Fifth and Sixth Generation Dentin Bonding Agent: An *in vivo* Study

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ABSTRACT

Introduction: The success of bonded restorations depends on effective bonding between restorative materials and tooth structure, and it prevents microleakage. New dentin bonding systems have been introduced which promotes this concept. The aim of this study was to compare the amount of microleakage between 'single bond' vs 'Prompt L-Pop' during different time periods.

Materials and methods: In this clinical trial study, 60 non-retentive class five cavities were prepared on buccal surfaces of human premolars which were scheduled to be removed for orthodontic purposes. The cavities were restored using two different bonding agents; fifth generation (Single Bond) and sixth generation (Prompt L-Pop) and then filled with resin composite (Filtek Z-250). The samples in both groups were extracted after placing the restoration in three periods of time: Immediately, 1 week and 6 months postplacement. Specimens were sealed with two layers of nail varnish except for 1 mm around restoration and immersed in a silver nitrate solution for 24 hours. The teeth were then sectioned longitudinally and the degree of microleakage was determined by stereomicroscope based on standard usual criteria.

Results: Single bond showed more leakage at dentin margin than enamel margin in all three extraction periods and differences were significant among three groups ($p < 0.05$). In samples which were restored with Prompt L-Pop only in groups of 6 months there were significant differences between enamel and dentin margins. At enamel margin there were no significant differences between microleakage of groups according to the passage of time ($p > 0.05$).

Conclusion: The results of this study using two different bonding systems, indicate that adhesion to enamel was more valuable than dentin and perhaps systems that include self-etching primers are less sensitive to remaining moisture on dentin and they are less affected during different time periods.

Keywords: Dental leakage, Dental adhesive, Resin composite.

How to cite this article: Samimi P, Barekatin M, Alaei S. Comparison of Microleakage of Composite Restorations using Fifth and Sixth Generation Dentin Bonding Agent: An *in vivo* Study. *J Contemp Dent Pract* 2012;13(5):632-636.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

One of the best predictors of the long-term success of bonded restorations is the ability of marginal sealing. The passage of oral fluids, bacteria, molecules and ions between cavity walls and restorative material is called microleakage.¹ Many postoperative failures are associated with microleakage, such as sensitivity, recurrent caries pulpal damage and breakdown of the restorative material.² The importance of microleakage in clinical conditions was first noticed when it was found that irritation is caused by bacteria and its endotoxin, not the restorative materials.³ Therefore, preventing microleakage and providing strong bonding between cavity wall and restorative material is an important consideration when applying bonding systems. A key factor in adhesion of bonding systems to dentin is the formation of a hybrid layer. Penetration of adhesive into the demineralized intratubular and intertubular dentin and formation of resin tags is the effective interlocking mechanism which can seal and prevent the permeability through dentin.⁴ None of the adhesive systems tested in several studies were able to completely prevent microleakage.⁵⁻⁷

Removal of hydroxiapatite crystals and denatured collagen fibrils with acid phosphoric etchant in dentin may cause the collagen fibril scaffold to collapse and lead to incomplete resin infiltration.⁸ Therefore, the etch and rinse systems cannot provide a perfect seal following demineralization by phosphoric acid and may lead to postoperative sensitivity and even bond failure.⁹

Self-etch adhesive systems which use nonrinse monomers were introduced to solve this problem and to

prevent discrepancies between the depth of demineralization and the depth of resin infiltration.¹⁰

Several studies have evaluated bond strength and microleakage of etch and rinse systems with those of self-etch adhesives.^{1,7,9,11} The main purpose of the present study was to compare the microleakage in restored teeth using a two-step (Single Bond), and a single step (Prompt L-Pop), adhesive systems. This study was done *in vivo*, making the results of microleakage more reliable.

MATERIALS AND METHODS

The current study was performed on 60 human caries-free premolars scheduled to be removed for orthodontic purposes. After informed consent was obtained from each patient, standardized class V cavities were prepared on the buccal surfaces of teeth with no mechanical retention using straight fissure carbide bur (SS white, Brazil). Dimensions of cavities were approximately 3 mm wide × 3 mm high × 1.5 mm deep with gingival margin in dentin.

The teeth were divided into the following six groups, based on the type of adhesive used and the different times of tooth extraction (Table 1). Adhesives used in this study were applied according to manufacturer's instructions (Table 2).

To test for microleakage, apical foramina were sealed with sticky wax and the entire surface of each tooth except for 1 mm around restorations was covered with two coats

of nail varnish. Samples were then immersed in 50% silver nitrate solution for 24 hours, after which they were washed with running water and placed in a photographic developing solution under a fluorescent light overnight. The teeth were sectioned longitudinally in the buccolingual direction with a diamond disk (D and Z, Germany).

Dye penetration was evaluated by a stereomicroscope at magnification 30×. Scoring was done according to the criteria shown in Table 3.

STATISTICAL ANALYSIS

Data were analyzed with Mann–Whitney, Wilcoxon and Kruskal-Wallis tests.

RESULTS

At enamel margin there were significant differences between microleakage of the two adhesive systems only in groups 3 and 4, in which teeth were extracted 1 week after placing the restoration ($p < 0.05$ and Fig. 1). At dentin margin, however, significant differences between the microleakage of two adhesive systems were seen in groups 1 and 2, where teeth were immediately extracted after restoration ($p < 0.05$ and Fig. 2).

Single bond adhesive systems showed more leakage at dentin margin than enamel margin in all three times of extractions and differences were significant among the three time periods ($p < 0.05$). In samples restored with Prompt

Table 1: Types of adhesives and restorative procedures used in the different groups as well as the time of extraction after restorative procedures were performed

| Groups (n = 60) | Type of adhesive used | Restorative procedures | Time of extraction | Other considerations |
|------------------|------------------------------|---|--|--|
| Group 1 (n = 10) | Single Bond (3M, ESPE, USA) | Filtek Z250 (3M, USA) used as hybrid resin composite, | Immediately after restorative procedures | None |
| Group 2 (n = 10) | Prompt L-Pop (3M, ESPE, USA) | which was placed in increments under 2 mm in thickness, each of which was light cured for 40 seconds. | Immediately after restorative procedures | None |
| Group 3 (n = 10) | Single Bond (3M, ESPE, USA) | Light output of the curing light used (Coltolux 50, Coltene, USA) was 1,500 mw/cm. ² Finishing was accomplished using finishing burs and Soflex (3M, USA) disks. | One week after restorative procedures | Patients were asked about postoperative sensitivity since the time of restorative procedures |
| Group 4 (n = 10) | Prompt L-Pop (3M, ESPE, USA) | | One week after restorative procedures | |
| Group 5 (n = 10) | Single Bond (3M, ESPE, USA) | | Six months after restorative procedures | restorative procedures |
| Group 6 (n = 10) | Prompt L-Pop (3M, ESPE, USA) | | Six months after restorative procedures | |

Table 2: Adhesive systems, composition and mode of application according to manufacturers' instructions

| Adhesive systems | Composition | Application mode |
|----------------------------|--|---|
| Adper Single Bond 3M ESPE | 37% phosphoric acid Bis-GMA, HEMA, dimethacrylates, polyalkenoic acid, camphorquinone, stabilizers, water and ethanol. | Acid etching (15 seconds), rinse (15 seconds) and air-dry, apply two coats of adhesive Air-dry (2-5 seconds), light-cure (10 seconds) |
| Adper Prompt L-Pop 3M ESPE | Liquid 1 (red blister): Methacrylated phosphoric esters; Bis-GMA; camphorquinone; stabilizers Liquid 2 (yellow blister): Water; HEMA; polyalkenoic acid; stabilizers. | Mixture of system (red and yellow blisters) Apply two coats with slight agitation (15 seconds) Air-dry (2-5 seconds), light-cure (20 seconds) |

L-Pop a significant difference between enamel and dentin margins was only seen in group 6, where extraction was performed after 6 months.

The Kruskal-Wallis test used to evaluate the effect of time on microleakage in different groups, revealed that in Single bond groups there were significant differences between microleakage at dentin margin in groups 1 (immediate extraction) and 3 (1 week extraction) ($p < 0.05$). At enamel margin there was no significant difference between microleakage of groups based on the passage of time.

In teeth restored with Prompt L-Pop, the different time periods of teeth extraction had no impact on leakage among the groups at enamel and dentin ($p > 0.05$).

Finally, in comparing the presence or absence of penetration leakage through dentin (score 4), 21 of 60 samples (35%) showed penetration leakage. Postoperative sensitivity was not a significant complaint made by patients, with only one patient in group 3, and two patients in group 4 reporting some sensitivity.

DISCUSSION

The ability of a bonded restoration to seal the interface of a tooth structure and restorative material is a key factor in preventing secondary caries.¹²

In several studies more leakage was shown at dentin margins than enamel margins.¹³⁻¹⁶ In this study also, less leakage was found at enamel margins in Single Bond (total-etch) adhesive than in Prompt L-Pop (self-etch) adhesive and there were significant differences between the microleakage of two systems in groups with 1 week extraction time. At dentin margin, Prompt L-Pop showed less leakage than Single Bond in groups where teeth were immediately extracted after restoration. These results were comparable to those of Gaillardia et al (2002) which compared microleakage of Single Bond, Excite and Prompt L-Pop adhesives. In their study total-etch adhesives revealed similar leakage scores in dentin when compared to self-etch systems.¹¹ Contrary to these findings, Waldman et al (2008) have noted that one step self-etch adhesives showed more leakage than total-etch or two step self-etch adhesives.¹ Chiaraputt et al (2011) verified that the values of microtensile bond strength of total-etch and two step self-etch adhesives is higher in comparison with one step self-etch adhesives.⁹

Since, the rinsing step is eliminated in self-etch adhesives, the moisture level of dentin and the issue of wet bonding is not a concerning factor in these adhesives. Since dentin is hydrophil and Prompt L-Pop is a water-based adhesive, the moisture within dentin or in dentinal tubules may improve the adhesive behavior.^{11,17,18}

Table 3: Scoring system used to evaluate dye penetration

| Score | In occlusal (enamel) margin | In gingival (dentin) margin |
|-------|---|---|
| 0 | No dye penetration | No dye penetration |
| 1 | Dye penetration in enamel to the dentin-enamel junction | Penetration of dye along the cavity wall, but less than 1/2 the length of the wall |
| 2 | Dye penetration in dentin, not including the axial wall | Penetration of dye along the cavity wall, but more than 1.2 mm the length of the wall |
| 3 | Dye penetration in dentin, including the axial wall | Penetration of dye to and along the axial wall |
| 4 | Ø | Penetration of dye into the pulp |

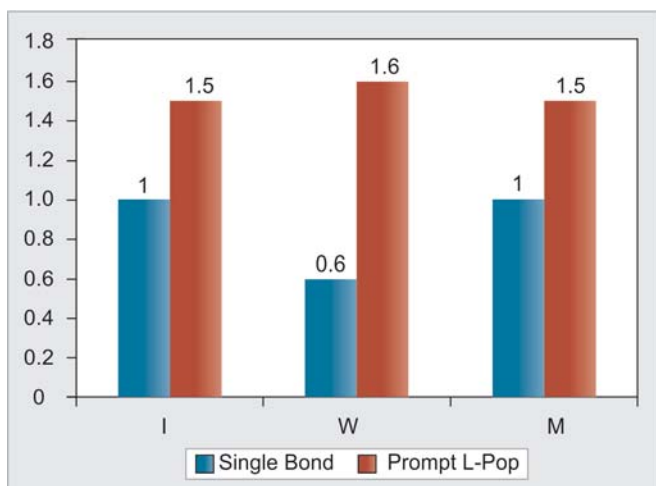


Fig. 1: Average amount of microleakage at enamel margin in different times of extraction (I = immediately, W = 1 week, M = 6 months extracted after restoration)

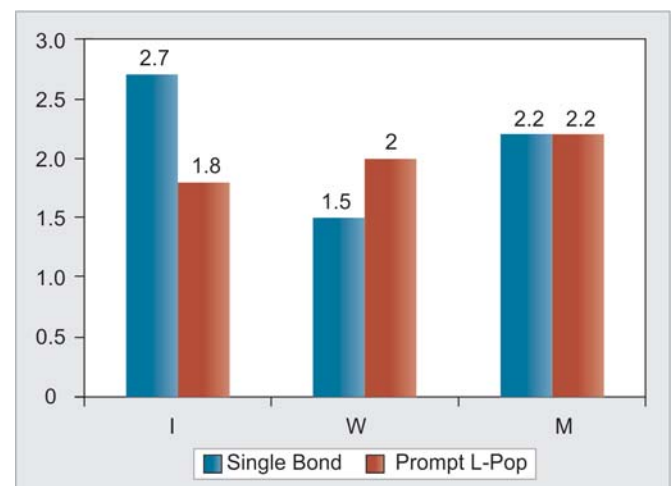


Fig. 2: Average amount of microleakage at dentin margin in different times of extraction (I = immediately, W = 1 week, M = 6 months extracted after restoration)

In applying self-etch primers on dentin especially the ones which have greater PH, the diffusion of acidic primers is not much, because of the density of the smear layer that is enriched with calcium and phosphor ions. In strong self-etch adhesives such as Prompt L-Pop (PH <1) if the depth of etching increases, buffering capability of dentinal tubules stops the increase and therefore the depth of etching and followingly the depth of resin infiltration restrict only to smear layer.¹⁹

From these two above-mentioned points, we concluded that self-etch adhesives show better results in their initial application than total-etch systems, since the depth of resin infiltration is equal to etching depth. But as reported in this study, because of limitation of resin infiltration into higher depth, after passage of 1 week and 6 months and due to thermo/mechanical load cycling and variant stresses in *in vivo* conditions, bond strength weakened and therefore self-etch adhesives showed equal or more microleakage than total-etch systems. These changes are associated with an increase in nanoleakage,²⁰ water tree phenomenon,²¹ and change in collagen fibril pattern over time.²²

As it was observed, enamel and dentin margins showed significant differences in microleakage in Prompt L-Pop groups after 6 months.

One step self-etching adhesives contain more water and hydrophilic resin, which can assist the diffusion of water from the hybridized dentin to the adhesive surfaces.²³ During thermal/mechanical cycling, stresses may cause separation at the interface and create more channels for the enzyme to hydrolyze the interface (hydrolytic degradation) over time.^{9,24}

The effect of time on bond strength and microleakage was investigated by several authors.^{9,25} In this study at enamel margins there were no significant differences in microleakage with passage of time with Single Bond adhesive; therefore it can be concluded that time has no effect on microleakage at enamel margins. At dentin margins in Single Bond groups, there were significant differences in microleakage between the groups immediately extracted and 1 week groups, and the amount of microleakage was decreased after 1 week. In comparing 1 week and 6 months groups, the passage of time lead to more microleakage, but the differences were not significant.

In Prompt L-Pop group at enamel and dentin margins, the passage of time had no effect on the amount of microleakage. This result was contrary to the Taledano et al study (2007), in which they found that microtensile bond strength of self-etch adhesives gradually decrease over time.²⁵ Also, Chiaraputt et al reported a greater percentage of adhesive failures in self-etch bonding systems after 3 months than in etch and rinse systems.⁹

Finally, it can be concluded that passage of time only affects microleakage of Single Bond adhesives at dentin margin. Microleakage first decreases and then increases. Findings in other adhesive groups were not significant. This might be explained by water absorption of composites. Most resin composites required 7 days to reach equilibrium and about 4 days to show the majority of expansion.³ Although Kempt et al exhibited that expansion due to water absorption had no significant effect on reduction of microleakage,²⁶ this expansion temporarily compensates the increase of microleakage due to passage of time. But after 1 week when composite resin reaches equilibrium, this compensation phenomenon stops and microleakage increases because of the hydrolytic effect of time.

CONCLUSION

The results of this study indicated that using two different bonding systems, adhesion to enamel was more valuable than dentin and perhaps systems that include self-etching primers are less sensitive to remaining moisture on dentin and they are less affected during different time periods.

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