

A Comparative Study of Cervical Composite Restorations Microleakage Using Dental Universal Bonding and Two-step Self-etch Adhesive

Kamyar Fathpour¹, Amirhosein Bazazzade², Hesam Mirmohammadi³

ABSTRACT

Aim: The aim of this study is to compare microleakage of cervical restorations using universal bonding and two-step self-etch adhesive with or without enamel etching through a dye penetration testing method.

Materials and methods: In this *in vitro* experimental study, 70 maxillary premolar teeth with no anomaly or decay were randomly divided into five groups of 14. Conventional cervical cavities were prepared with diamond bur on the facial surface of the teeth. The teeth were prepared using G-Premio Bond/self-etch technique, G-Premio Bond/total-etch technique, G-Premio Bond/selective-etch technique, Clearfil SE Bond/self-etch technique, and Clearfil SE Bond/selective-etch technique in Groups I to V, respectively, and restored with composite. Microleakage at the occlusal enamel margin and the cervical dentinal margin was ranked from 0 to 4 based on dye penetration using stereomicroscope (×32). Statistical analysis was carried out using Kruskal-Wallis and Mann-Whitney tests at a significance level of $\alpha = 0.05$.

Results: The mean occlusal microleakage in the five study groups was 1.07, 0.57, 0.57, 1.28, and 0.78, respectively. The mean cervical microleakage was 0.97, 0.85, 0.64, 1.35, and 1.14, respectively. Kruskal-Wallis test showed significant difference between the microleakage scores of different groups in enamel ($p = 0.022$) and dentin ($p = 0.01$). Clearfil SE Bond/self-etch technique group showed the highest mean score of microleakage in enamel margins, and G-Premio Bond/total-etch technique and G-Premio Bond/selective-etch technique groups showed lowest enamel microleakage mean. Clearfil SE Bond/self-etch group showed the highest mean score of microleakage in dentin margins, while G-Premio Bond/selective-etch technique group showed the lowest mean score of dentin microleakage.

Conclusion: Selective etching of enamel will decrease enamel microleakage. G-Premio Bond shows better microleakage results in comparison to Clearfil SE Bond in dentinal margins.

Clinical significance: A major problem in cervical composite restorations is the presence of microleakage in the cervical wall. Different adhesive systems have been designed to overcome this problem.

Keywords: Microleakage, Selective enamel etch, Self-etch bonding, Universal bonding.

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INTRODUCTION

One of the remarkable progresses in restorative dentistry is the technology of resin-based composites.¹ Composite restorations have certain advantages over amalgam restorations including preservation and adhesion to tooth structure.² Restoration of cervical cavities is one of the indications of composite resins.^{3,4} Microleakage, defined as the diffusion of the bacteria, fluids, molecules, and/or ions into the space between the walls of the cavity and the restorative materials, is a major problem in cervical composite restorations^{4,5} resulting in marginal discoloration, sensitivity, recurrent caries, pulp irritation, and eventually failure of the restoration. Therefore, it is necessary to prevent microleakage when using an adhesive system.⁶ One of the limitations of cervical lesion is the high C-factor in this restoration that increases the degree of marginal microleakage.^{7,8}

Perfect adaptation between restorative materials and cavity margins is necessary for achieving a successful restoration.^{9,10} Currently, dental adhesive systems provide a favorable marginal seal and reduce marginal microleakage in composite restorations.¹¹ Many studies have measured the degree of microleakage in cavities restored with dentin bonding systems, but no system has been able to prevent microleakage completely.¹²

There are two strategies for modern dental adhesive systems: Etch-and-rinse systems and self-etch systems with different steps of application.^{13,14} Nowadays, various types of adhesive systems are

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available and there are ongoing studies to simplify and improve the performance of these systems.¹⁵ Three-step etch and rinse systems

and two-step self-etch systems have shown decent clinical results in many studies.^{13,16,17} Different studies show different results of microleakage for adhesive systems.¹⁸ Some studies have shown that self-etch systems are as effective as etch and rinse systems in preventing microleakage.^{19,20} Nowadays, universal adhesives, which can be used in the self-etch, Total Etch, or Selective-etch technique, are being used. These adhesives can create bond to different substrates including dentin, enamel, glass ionomers, metals, and ceramics.²¹

In a review study by Shroeder et al.,²² it was concluded that the adhesive strategy, self-etch mode or etch and rinse mode, did not influence the postoperative sensitivity and the retention rates of composite resin in NCCLs in any of the follow-up periods, but less marginal discoloration was found in etch-and-rinse adhesives. In a study by Khosravi et al.²³ on the degree of enamel microleakage using Clearfil SE Bond, I-Bond, and Scotchbond Multipurpose adhesive systems, it was concluded that the difference in enamel microleakage was not significant when using Clearfil SE Bond in self-etch or Selective-etch mode. Another study by Kermanshah et al.²⁴ showed that using Scotchbond Universal in Total-etch mode resulted in lower degrees of microleakage in enamel margins than self-etch mode. Gupta et al.²⁵ concluded that there is no difference between degree of microleakage in composite cervical restorations using two step self-etch and Universal bondings.

It seems that adhesive application strategy and chemical composition of the adhesive affect the degree of microleakage in dentin and enamel margins. The aim of this study was to measure and compare the degree of microleakage in enamel and dentinal margins in cervical restorations using Universal bonding and two-step self-etch bonding with or without enamel etching.

MATERIALS AND METHODS

The research protocol of this *in vitro* experimental study was approved by the ethic research committee of Isfahan University of Medical Sciences, Iran (IEC#IR.MUI.REC.1397.3.119).

Sample Preparation

Seventy maxillary premolar teeth with no anomaly or decay extracted for orthodontic reasons were used in this study (significance level of $\alpha = 0.05$). Teeth were cleaned using ultrasonic device (Varios2 Ultrasonic Scaler, NSK, Japan) to remove external debris and stains, stored in 0.5% thymol solution for 1 week and kept in normal saline to prevent dehydration. Conventional class V cavities, 3 mm wide, 1.5 mm deep, and 1.2 mm height (Fig. 1) were prepared on the facial surface of the teeth parallel to the cemento-enamel junction using high-speed 1.2 mm diamond cylindrical bur (Tizkavan-Iran). The cervical margin of the preparation was located in dentin and the occlusal margin was located in enamel. The cavities were washed with water for 20 seconds and then dried using an air syringe. Each bur was used to prepare four cavities.

Bonding Procedure

In this study, G-Premio Bond (GC, Tokyo, Japan) was used as universal bonding and Clearfil SE Bond (Kuraray, Tokyo, Japan) as two-step self-etch adhesive. The teeth were assigned to five different groups:

Group I: Use of G-Premio Bond in self-etch mode (GSE): According to the manufacturer's instructions, one layer of G-Premio Bond was

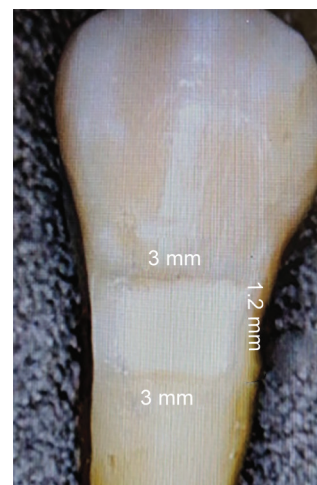


Fig. 1: Prepared cavity dimensions

rubbed onto the cavity surface for 20 seconds with a microbrush. The bond remained on the cavity surface for 10 seconds and the cavity was dried at the maximum airflow rate for 5 seconds. Finally, the adhesive layer was light cured at a light intensity of 800 mW/cm² for 10 seconds using VALO Grand device (Ultradent, United States).

Group II: Use of G-Premio Bond in total-etch mode (GTE): 35% phosphoric acid (Ultradent, United States) was applied to the enamel margins and subsequently to dentin for 15 seconds. After rinsing with air/water spray for 20 seconds, the cavity surface was dried under gentle air pressure until the frosty appearance of the enamel was visible. The procedure of applying G-Premio Bond was similar to Group I.

Group III: Use of G-Premio Bond in selective-etch mode (GSEL): 35% phosphoric acid was applied to the enamel margins for 20 seconds. After rinsing with air/water spray, the cavity surface was dried under gentle air pressure until the frosty appearance of the enamel was appeared. The procedure of applying G-Premio Bond was similar to Group I.

Group IV: Use of Clearfil SE Bond in self-etch mode (SESE): Following manufacturer's instructions, Clearfil SE Bond primer was rubbed onto the cavity for 20 seconds with a microbrush, the cavity was dried using gentle air pressure for 10 seconds. Subsequently one layer of the Clearfil SE Bond adhesive component was applied onto the cavity with a microbrush and air thinned for 10 seconds using gentle air flow. Finally, the adhesive layer was cured at a light intensity of 800 mW/cm² for 10 seconds using VALO Grand device.

Group V: Use of Clearfil SE Bond in selective-etch mode (SESEL): 35% Phosphoric acid was applied to the enamel margins for 20 seconds. After rinsing with air/water spray for 20 seconds, the cavity surface was dried under gentle air pressure until the frosty appearance of the enamel was appeared. The procedure of applying Clearfil SE Bond is similar to Group IV.

A₂ Gradia Direct composite resin (GC, Tokyo, Japan) which is a light-cured microhybrid composite resin was used to restore cervical cavities in three layers on gingival floor, occlusal wall, and the remaining cavity, respectively (Fig. 2). Each layer was light cured at a light intensity of 800 mW/cm² for 20 seconds using VALO Grand device.

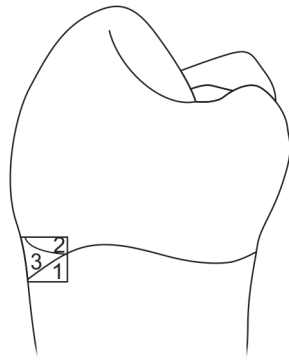


Fig. 2: Layers of composite in cervical cavity

The specimens were finished using flame shape composite resin finishing burs (Tizkavan-Iran). Each bur was used to finish four specimens. The specimens were polished using Soflex polishing disks (3M, Minnesota, United States) which is a four-step composite resin polishing system. Each color coded disk was applied for 5 seconds on the composite surface. Postcuring of the specimens was achieved at a light intensity of 1200 mW/cm² for 3 seconds. The specimens were stored in distilled water at 37°C for 24 hours. Thermo-cycling was carried out at temperatures of 5 ± 5°C and 55 ± 5°C for 1,000 cycles with a storage time of 30 seconds per cycle.

Microleakage Test

All specimens were coated with two layers of varnish within a distance of 1 mm to the margin of the restoration, immersed in 2% fuchsin at room temperature for 24 hours and washed with distilled water. The specimens were cut buccolingually right from the middle of the restoration using cutting instrument (Vafaei Industrial Co., Tehran, Iran). Microleakage at the occlusal enamel margin and the cervical dentinal margin was observed using a stereomicroscope (10-MBC, HP, United States) at a magnification of ×32 and scored as follows:²⁶

- 0: No microleakage found
- 1: Dye penetration by one-third of the cavity depth
- 2: Dye penetration by two-thirds of the cavity depth
- 3: Dye penetration by more than two-thirds of the cavity depth
- 4: Dye penetration reaching the axial wall or towards the tooth pulp

Finally, the mean score of microleakage was calculated for each group. Data were statistically analyzed with Kruskal-Wallis and Mann-Whitney tests at a significance level of $\alpha = 0.05$.

RESULTS

Table 1 provides the mean scores of microleakage in five study groups. SESE group showed the highest mean score of microleakage (1.28) and GTE and GSEL groups showed the lowest (0.57) in enamel margins. SESE group showed the highest mean score of microleakage (1.35) and GSEL group showed the lowest score (0.64) in dentinal margins. Table 2 shows the dispersion percentage of occlusal enamel microleakage and Table 3 illustrates the dispersion percentage of cervical dentin microleakage in five study groups.

Kruskal-Wallis test showed that there is a significant difference between the degree of occlusal microleakage ($p = 0.022$) in the

Table 1: Mean scores of microleakage in the study groups

Bonding method	Occlusal margin	Cervical margin
GSE	1.07 ^(ab)	0.97 ^(cdf)
GTE	0.57 ^(a)	0.85 ^(cd)
GSEL	0.57 ^(a)	0.64 ^(c)
SESE	1.28 ^(b)	1.35 ^(e)
SESEL	0.78 ^(a)	1.14 ^(ef)

Groups with the same superscript in the same row are not statistically different ($p > 0.05$); GSE, G-Premio Bond in self-etch mode; GTE, G-Premio Bond in total-etch mode; GSEL, G-Premio Bond in selective-etch mode; SESE, Clearfil SE Bond in self-etch mode; SESEL, Clearfil SE Bond in selective-etch mode

five study groups. Also, cervical microleakage difference between five groups was significant ($p = 0.01$). Based on Mann-Whitney test results, occlusal microleakage was significantly higher in SESE group than GTE ($p = 0.009$), GSEL ($p = 0.009$), and SESEL ($p = 0.035$) groups, while difference between other groups was not significant ($p > 0.05$). Also, Mann-Whitney test showed that cervical microleakage was significantly higher in SESE group than GSE ($p = 0.011$), GTE ($p = 0.008$), and GSEL ($p = 0.002$) groups. Comparison of cervical microleakage between SESEL group and the other groups showed that cervical microleakage was significantly higher in this group than GTE ($p = 0.05$) and GSEL ($p = 0.008$) groups, while difference between other groups was not significant ($p > 0.05$).

DISCUSSION

Application of adhesives with separate steps of etching, priming, and bonding resin increases technical sensitivity which is considerably reduced when using self-etch primers that protect smear layer.^{27,28} Strong self-etch systems ($\text{pH} < 1$) etch the smear layer completely similarly to etch-and-rinse adhesive systems, whereas ultra-mild adhesive systems ($\text{pH} > 2.5$) leave the tubules of the smear layer intact. The partial demineralization, which occurs with application of mild self-etch systems ($\text{pH} = 2.5$) (such as Clearfil SE Bond) and ultra-mild self-etch systems, allows for the occurrence of chemical interactions between some functional monomers (such as MDP and 4-META) and hydroxyapatite crystals remaining among collagen fibers.²⁹ It seems that the effectiveness of two-step self-etch bonding systems is related to occurrence of chemical and micromechanical bonding.^{30,31}

In this study, the significant difference of enamel margin microleakage between SESE group and GTE/GSEL/SESEL groups indicates the importance of acid application on enamel margins for reduction of microleakage. Moreover, the degree of dentinal microleakage was significantly higher in SESE group than in GSE/GTE/GSEL groups indicating the fact that if acid is not applied prior to application of Clearfil SE Bond, G-Premio Bond shows lower scores of microleakage when used in self-etch, Total Etch, and Selective Etch mode which is due to the specific composition of G-Premio Bond (Table 1).

According to the findings of Hannig et al.,³² the application of two-step self-etch adhesives on enamel margins creates effective micromechanical bond. Meanwhile, a review by Osorio et al.³³ shows that no adhesive eliminates microleakage completely. They concluded that Clearfil SE Bond shows lower degrees of microleakage in cervical margins of the restoration.

Table 2: Different scores of enamel microleakage in the study groups N (%)

Groups/microleakage score	0	1	2	3	4	Total
GSE	4 (28.57%)	5 (35.71%)	5 (35.71%)	0 (0%)	0 (0%)	14
GTE	6 (42.68%)	8 (57.14%)	0 (0%)	0 (0%)	0 (0%)	14
GSEL	6 (42.68%)	8 (57.14%)	0 (0%)	0 (0%)	0 (0%)	14
SESE	2 (14.29%)	6 (42.86%)	6 (42.86%)	0 (0%)	0 (0%)	14
SESEL	3 (21.43%)	11 (78.57%)	0 (0%)	0 (0%)	0 (0%)	14

0, No microleakage found; 1, Dye penetration by one-third of the cavity depth; 2, Dye penetration by two-thirds of the cavity depth; 3, Dye penetration by more than two-thirds of the cavity depth; 4, Dye penetration reaching the axial wall or towards the tooth pulp

Table 3: Different scores of dentin microleakage in the study groups N (%)

Groups/microleakage score	0	1	2	3	4	Total
GSE	1 (7.14%)	13 (92.86%)	0 (0%)	0 (0%)	0 (0%)	14
GTE	2 (14.29%)	12 (85.71%)	0 (0%)	0 (0%)	0 (0%)	14
GSEL	5 (36.71%)	9 (64.29%)	0 (0%)	0 (0%)	0 (0%)	14
SESE	0 (0%)	9 (64.29%)	5 (35.71%)	0 (0%)	0 (0%)	14
SESEL	0 (0%)	12 (85.71%)	2 (14.29%)	0 (0%)	0 (0%)	14

0, No microleakage found; 1, Dye penetration by one-third of the cavity depth; 2, Dye penetration by two-thirds of the cavity depth; 3, Dye penetration by more than two-thirds of the cavity depth; 4, Dye penetration reaching the axial wall or towards the tooth pulp

Studies have shown that when phosphoric acid is not used for etching, higher degrees of microleakage are observed in the enamel margins.^{34,35} The present study also shows that the degree of enamel microleakage is significantly lower when Clearfil SE Bond is used in selective-etch mode than self-etch mode. In addition, the degree of enamel microleakage is significantly lower when G-Premio Bond is used in total-etch mode and selective-etch mode than self-etch mode. These significant differences indicate the importance of acid application at enamel margins.

HEMA (hydroxyethylmethacrylate) contained in G-Premio Bond composition may expand dentin collagen fibrils, which in turn leads to increased permeability of the adhesive monomers in the demineralized dentin.³⁶ In addition, the water content in G-Premio Bond is approximately 25%, and the pH of this bond is 1.5. When dentin surface is dried, the water content in the adhesive starts initial ionization of the acidic component and rewets the dried surface of the dentin. Thus, G-Premio Bond is capable of re-expanding the air-dried and collapsed collagen network in order to facilitate the diffusion of resin adhesives.³⁷ In addition, the presence of functional monomers such as 4-META, MDP-10, and MDTP in G-Premio Bond may improve bonding performance by interactive effect and increased penetration of monomers into the compressed smear layer.³⁸ Therefore, the lower scores of dentinal microleakage with G-Premio Bond in different modes of application compared to Clearfil SE Bond in self-etch mode can be attributed to a better resin adhesive diffusion of monomers into the air-dried and collapsed collagen network. The presence of water and HEMA in the G-Premio Bond adhesive re-expands collagen fibrils which increases permeability of the functional monomers into the demineralized dentin. Hence this bonding can be used in total-etch or self-etch modes. Dentin surface is completely air dried and the collagen collapse will be compensated.

The present study showed that no adhesive system could completely eliminate microleakage. Moreover, the degree of

dentinal microleakage was significantly higher in SESE group than GSE, GTE, and GSEL groups (Table 1), indicating that if phosphoric acid is not applied prior to application of Clearfil SE Bond, the microleakage scores of G-Premio Bond will be lower in different modes.

In a systemic review by Szesz et al.³⁹ on the effect of selective etching technique for restoring cervical lesions with self-etch adhesives, they concluded that selective etching of enamel margins prior to application of self-etch adhesive systems in noncarious cervical lesions can produce composite restorations with higher longevity. Their review showed that less loss of retention of the restorations at the 3-year follow-up was observed with the selective etching of enamel when using self-etch adhesives. Lower scores of microleakage when using acid in enamel margins in our study are in accordance with this systemic review. In a study by Kearns et al.,⁴⁰ a significant difference was observed between the degrees of cervical microleakage when Scotchbond Universal adhesive and Prime and Bond Elect Universal adhesive were used in the self-etch mode and total etch mode but no significant difference was observed between the degrees of cervical microleakage when Futurabond U was used in the self-etch mode and total etch mode. Their study confirms that it is essential to separately evaluate the microleakage of each adhesive system along with their specific formulations and steps. Also, comparing results between present study and studies conducted by Khosravi et al.,²³ Kermanshah and Khorsandian²⁴ and Gupta et al.²⁵ indicates the importance of adhesive chemical composition and mode of application on the microleakage of the composite restorations.

The main limitation of this study is that microleakage test was done immediately after bonding process and thermocycling. It is necessary to assess microleakage after long period of time. Also it is necessary to assess chemical, mechanical, and biological degradation on microleakage.

CONCLUSION

Given the limitations of this study, the application of phosphoric acid gel prior to bonding process decreases microleakage score for both tested adhesives (G-Premio Bond and Clearfil SE Bond). In dentin margins G-Premio Bond showed less microleakage scores than Clearfil SE Bond with different modes of application.

CLINICAL SIGNIFICANCE

A major problem in cervical composite restorations is the presence of microleakage in the cervical wall. Different adhesive systems have been designed to overcome this problem.

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