Original Article

# In Vitro Microleakage of Class V Composite Restorations in Use of Three Adhesive Systems

**F. Motevaselian [1], E. Yassine [2], M. Mirzaee [3]✉, MJ. Kharazifard [4], S. Heydari [5], M. Shafiee [6].**

[1] Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[2] Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[3] Associate Professor, Dental Research Center, Dentistry Research Institute, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[4] Research Member, Dental Research Center, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran
[5] PhD, Student of Dental Material, Tehran University of Medical Sciences, Tehran, Iran
[6] Dentist, Private Office, Tehran, Iran

**Abstract**

**Background and Aim:** Microleakage is a drawback of composite restorations and it is more noticeable in dentinal walls. Despite advances in dentin bonding agents, no adhesive can completely eliminate microleakage and provide a hermetic seal. This study aimed to compare microleakage of three resin bonding agents namely a universal adhesive, two-step self-etch system and two-step total-etch system.

**Materials and Methods:** This in vitro, experimental study was conducted on 68 human molars. Class V cavities were prepared in the buccal or lingual surfaces of the teeth with occlusal margins in the enamel and gingival margins in dentin. The teeth were then randomly divided into four groups of 17. Group A: Adper Single Bond 2, group B: Clearfil SE Bond, group C: Scotchbond Universal adhesive (self-etch) and group D: Scotchbond Universal adhesive (total-etch). The teeth were then restored using different bonding agents and a microhybrid composite resin. The specimens were then subjected to 1000 thermal cycles between 5-55°C. The entire restoration surface except for 1mm around the margins was coated with nail varnish. The teeth were immersed in 2% methylene blue for 24 hours and sectioned longitudinally in a buccolingual direction and observed under a stereomicroscope to determine microleakage. Microleakage in use of the three bonding agents was compared using the Kruskal Wallis test ($P<0.05$).

**Results:** Based on the Kruskal Wallis test, no significant difference was noted in enamel and dentin margins among different adhesives but the enamel margin showed less microleakage than the dentin margin.

**Conclusion:** Different adhesive systems tested in this study showed similar microleakage at the enamel and dentinal margins.

**Key Words:** Dentin-Bonding Agents, Composite Resins, Dental Leakage

✉ Corresponding author:
M. Mirzaee, Associate Professor, Dental Research Center, Dentistry Research Institute, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran

*mirzaiim@tums.ac.ir*

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## Introduction

Advances have been made in tooth-colored restorative materials. Polymerization shrinkage of composite resins produces stress between bonded restorations and cavity walls resulting in gap formation and microleakage. Marginal adaptation of adhesive to tooth structure can prevent microleakage and subsequent caries recurrence and pulpal irritation [1]. Acidic conditioners such as phosphoric acid were first used to condition the

tooth structure. In newer generations of bonding agents, acidic conditioning step has been eliminated and replaced with a primer containing acidic monomers, which etch and prime simultaneously. Simplification of bonding steps resulted in introduction of All-in-One adhesives, which can do etching, priming and bonding all in one step. In multi-step bonding, an acidic conditioner is used, which is rinsed with water and air-dried. However, it is associated with risk of over-drying of demineralized dentin or collapse of collagen network. Inadequate washing is another possibility, and residual acids can over-etch dentin, or reaction products may occlude the spaces around collagen fibers [2]. Composite resins are commonly used in restorative dentistry due to optimal esthetics and conservative preparation [3]. Polymerization shrinkage is one major problem of light cure composites, which can cause a gap between the light cure composite and tooth structure especially in dentin margins [4]. This gap can serve as a site for saliva and bacterial accumulation [5]. Microleakage can cause tooth hyper-sensitivity, secondary caries, pulpal inflammation and fracture of restoration [6]. Microleakage depends on factors such as size and shape of cavity, type of dentin substrate, margin of the prepared cavity and the used method [7]. Restoration of class V cavities with composite resin requires a strong bond between restorative material and enamel and dentin margins. Dentin provides a weaker bond compared to enamel and obtaining a durable dentin bond is difficult. No material is available to create a hermetic seal at dentin margins [8]. Dentin bonding agents have been modified to create a strong dentin bond. This study aimed to compare the microleakage of three resin bonding agents namely a universal adhesive, a two-step self-etch and a two-step total-etch system.

## Materials and Methods

In this in vitro, experimental study, 68 sound human molars without caries and cracks were chosen. The teeth were cleaned from debris and immersed in 5% chloramine solution for one week for disinfection. After rinsing and drying, the teeth were stored in saline. Class V cavities were prepared in the buccal or lingual surfaces measuring 1.5 mm in depth, 3 mm in mesiodistal width and 3 mm in occlusogingival height using a carbide fissure bur with 0.8 mm diameter (D & Z, Wies Baden, Germany). The bur was changed for every five teeth. Gingival margin was placed 1 mm below the cementoenamel junction. The teeth were then randomly divided into four groups of 17.

Group A. Adper Single Bond 2 total-etch (3M ESPE, St. Paul, MN, USA)

Group B. Clearfil SE Bond self-etch (Kuraray, Tokyo, Japan)

Group C. Scotch bond Universal adhesive self-etch (3M ESPE, St. Paul, MN, USA)

Group D. Scotch bond Universal adhesive total-etch (3M ESPE, St. Paul, MN, USA). A5 shade of vit-l-escence composite (Ultradent Inc., UT, USA) was used for restoration of cavities.

In group A, after cavity preparation, enamel margins were etched with 37% phosphoric acid for 15 seconds and dentin margins were etched for 5 seconds. After 15 seconds of rinsing, they were dried gently and dentin remained slightly moist. Two layers of Adper Single Bond 2 were applied on the cavity walls and each layer was air sprayed for solvent evaporation and cured for 10 seconds with LED light curing unit (Demetron, Kerr, Orange, CA, USA) with a light intensity of 700 $mW/cm^2$. Next, micro-hybrid composite was applied in two oblique layers and each layer was cured for 40 seconds.

In group B, after cavity preparation, primer was applied to the entire cavity for 20 seconds and subjected to mild air spray for 5 seconds. Using a micro-brush, bonding agent was applied to the entire cavity wall and cured for 10 seconds. In the next step, micro-hybrid composite was applied in two oblique layers and cured for 40 seconds.

In group C, after cavity preparation, Scotchbond Universal adhesive was applied in self-etch mode with a micro-brush and rubbed on dentin and enamel margins for 20 seconds. After gentle air spray for 5 seconds, curing was done for 10 seconds. Micro-hybrid composite was then applied in two layers and cured for 40 seconds.

In group D, after cavity preparation, enamel margins were etched with 37% phosphoric acid for 15 seconds and dentin margins were etched for 5 seconds. After rinsing and drying for 15 seconds, adhesive was applied as in group C and cured for

10 seconds. Micro-hybrid composite was applied as explained earlier and cured for 40 seconds. Restored teeth were then polished with polishing discs (Sof-Lex, 3M ESPE, St. Paul, MN, USA). The specimens were then immersed in distilled water at 37°C for 24 hours and were then subjected to 1000 thermal cycles between 5-55°C with 30 seconds of dwell time. Root apex was sealed with sticky wax and the entire surface was coated with two layers of nail varnish except for 1mm around the restoration margin. The samples were immersed in 2% buffered methylene blue at 37°C for 24 hours and after rinsing, they were sectioned from the occlusal surface parallel to the longitudinal axis of the tooth. Microleakage was evaluated under a stereomicroscope at x20 magnification. Each specimen was evaluated twice randomly by two observers [9]. Microleakage in the enamel and dentin margins was scored as follows:

0: No dye penetration
1: Dye penetration to one-third of the cavity wall
2: Dye penetration to two-thirds of the cavity wall
3: Dye penetration to the axial wall

## Results

No significant difference was noted in microleakage of dentinal margins among the groups (P=0.06). In enamel margins, microleakage of Adper Single Bond 2 and Scotchbond Universal adhesive (total-etch) was lower than that in the other groups but not significantly (P>0.05, Table 1). In dentin margins, microleakage in Scotchbond Universal adhesive (self-etch) and Clearfil SE Bond was less than that in other groups but this difference was not significant (P>0.05, Table 2).

Kruskal Wallis test compared microleakage in the three groups and found no significant difference in the enamel (P=0.2) or dentin (P=0.06) margins but microleakage in enamel margins was significantly lower than that in dentin margins (P<0.05).

Table 2 shows the frequency of microleakage scores in dentin margins. No significant difference was noted in microleakage at dentin margins in different groups (P>0.05).

## Discussion

In this study, microleakage in the enamel and dentin margins was evaluated following the use of different adhesives and the results showed that microleakage at the enamel margin was significantly lower than that in dentin margins. No significant difference was noted in microleakage at the enamel or dentin margins among the groups. Several studies have assessed microleakage in enamel and dentin margins using self-etch and total-etch adhesive systems and have shown less microleakage in enamel compared to dentin margins [9,10]. Enamel, due to having high mineral content, has a more homogenous structure, superior ability to bond to bonding agents and less microleakage. Thus, it provides a more reliable bond compared to dentin [11]. Dentin contains significant amount of water and minerals and is mainly composed of type I collagen and a dense network of tubules. These tubules are mainly branched at the cementoenamel junction and these branches of tubules on the root surface are more frequent than in coronal dentin. Acid etching of this surface with phosphoric acid or even acidic monomers present in self-etch system can lead to change in surface morphology or chemical composition. Moreover, orientation of dentinal tubules can change the formation of hybrid layer [12]. Thus, higher scores of microleakage in dentin margin by use of self-etch and total-etch systems may be due to changes in this surface. In clinical conditions, cavity margins are placed in dentin and moisture control and access are more difficult. Thus, multi-step bonding systems have higher risk of failure and use of self-etch systems that simplify clinical procedures may have lower technical sensitivity and higher success rate. Clearfil SE Bond does not etch the enamel as efficient as the phosphoric acid and seal of enamel margins in the clinical setting may be incomplete. But, bond strength of new self-etch primers has gradually improved such that researchers claim that two-step mild or ultra-mild self-etch adhesives can serve as a suitable alternative to two-step and three-step etch and rinse systems [13].

Clinical success of Clearfil SE Bond may be due to the fact that with a pH of 2, it creates adequate micromechanical retention in the enamel surface. Also, its chemical formulation contains 10-MDP with long carbonyl chains which confer hydrophobic properties and hydrolytic stability to this monomer. This monomer forms chemical bond

**Table 1.** Frequency of microleakage scores in the enamel margin (n=34)

| Adhesive | Microleakage score | | | |
|---|---|---|---|---|
| | Score 0 Number (percentage) | Score 1 Number (percentage) | Score 2 Number (percentage) | Score 3 Number (percentage) |
| **Adper Single bond 2** | 24(70.6) | 6(17.6) | 1(2.9) | 3(8.8) |
| **Clearfil SE Bond** | 22(64.7) | 7(20.6) | 0 | 5(14.7) |
| **Scotchbond Universal Adhesive(self-etch)** | 17(50) | 9(26.5) | 1(2.9) | 7(20.6) |
| **Scotchbond Universal Adhesive(total etch)** | 26(76.5) | 0 | 0 | 8(23.5) |
| **Total** | 89(65.4) | 22(16.2) | 2(1.5) | 23(16.9) |

**Table 2.** Frequency of microleakage scores in the dentin margin (n=34)

| Adhesive | Microleakage score | | | |
|---|---|---|---|---|
| | Score 0 Number (percentage) | Score 1 Number (percentage) | Score 2 Number (percentage) | Score 3 Number (percentage) |
| **Adper Single bond 2** | 4(11.8) | 2(5.9) | 4(11.8) | 24(70.6) |
| **Clearfil SE Bond** | 15(44.1) | 1(2.9) | 1(2.9) | 17(50) |
| **Scotchbond Universal Adhesive(self-etch)** | 14(41.2) | 2(5.9) | 1(2.9) | 17(50) |
| **Scotchbond Universal Adhesive(total etch)** | 6(17.6) | 8(23.5) | 4(11.8) | 16(47.1) |
| **Total** | 39(28.7) | 13(9.6) | 10(7.4) | 74(54.4) |



by formation of calcium-phosphate salts with hydroxyapatite without causing severe decalcification. This chemical bond mediated by 10-MDP has higher stability in water compared to the bond of other monomers present in other self-etch adhesives such as 4-META and phenyl P. These factors may explain similar microleakage of two-step self-etch system and two-step etch and rinse system in our study [13,14]. A previous studyhas reported 98% retention of class V cavities restored with Clearfil SE Bond after 8 years and 100% after two years in posterior restorations [14]. Amarliet al. reported the same behavior in enamel margins in use of self-etch and total-etch systems [15]. Recent advances in adhesive systems resulted in introduction of Scotchbond Universal adhesive by 3M which can be applied in self-etch and total-etch modes. The pH of this adhesive is 2.7, which is considered mild compared to phosphoric acid. Thus, phosphoric acid may be preferred for

application on prepared or sound enamel. According to the manufacturer, the success of this adhesive is due to two factors:

1.MDP monomer causing better bond to tooth structure

2.Polyalkenoic acid VitreBond copolymer which is effective in chemical bond to tooth structure.

Scrubbing of adhesive for 20 seconds on tooth surface is recommended. According to the manufacturer, a high percentage of tested samples show continuous margins in both self-etch and total-etch modes. Nonetheless, selective enamel etching is suggested by the manufacturer to enhance bond to the enamel [16,17]. In our study, microleakage at the dentin margin was the same in all three adhesive groups. For universal adhesive, microleakage was the same in self-etch and total-etch modes and it may be concluded that a separate etching step is not clinically required to decrease microleakage. This finding may be due to the specific composition of this adhesive. As stated earlier, it contains 10-MDP (also present in CSEB) which can provide a stable chemical bond and VitreBond copolymer which enables a bond to dry and wet dentin [16,18]. Perdigoet al. restored class V cavities using Scotchbond Universal and showed that it yielded the same results in terms of shear bond strength in self-etch and total-etch modes [17]. Scotchbond Universal adhesive enables the use of both modes but the main purpose behind introduction of this adhesive was to introduce a self-etch one-step adhesive with the mechanism of using functional monomers to chemically bond to hydroxyapatite with simultaneous etching and penetration of adhesive. Similarity between Scotchbond Universal adhesive and Adper Single Bond 2 is due to the presence of polyalkenoic acid copolymer in both systems. Similarity between Scotchbond Universal adhesive and Clearfil SE Bond is due to the presence of MDP monomer [16-18,19]. Effect of Adper Single Bond 2 is weaker on dentin because under wet bonding conditionsthe adhesive incompletely diffuses causing a porous collagen network. Also, this adhesive is a combination of functional primer and three-step conventional adhesive with solvents such as water and alcohol in its composition [15]. Phase separation occurs due to water sorption at the interface between the hydrophobic resins and hydrophilic primers. This effect may be modulatedby the presence of high molecular weight polyalkenoic acid and HEMA. Presence of alcohol as a solvent may explain its efficacy [20,21] and increase its penetration into dentin [15]. In the study by Gagliardiet al, dentin margin microleakage was the same in use of self-etch and etch and rinse modes, which was in line with our results [22].

## Conclusion

The results showed that Scotchbond Universal adhesive yielded similar microleakage compared to other bonding agents such as Clearfil SE Bond. Thus, Scotchbond Universal may be used as an alternative to other adhesive systems due to simpler application and fewer procedural steps.

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