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# Effects of a Universal Adhesive System and the Snow-Plow Technique on Microleakage of Class II Composite Restorations in Primary Molars

Mahshid Gifani[1], Mahsa Talafi Noghani[1], Alireza Sarraf Shirazi[1,2], Alireza Boruziniat[2]*

1. Department of Pediatric Dentistry, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran
2. Dental Research Center, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

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**** Corresponding author:***
Dental Research Center, School of Dentistry, Mashhad University of Medical Sciences, Mashhad, Iran

Email: borouziniata@mums.ac.ir

**ABSTRACT**

**Objectives:** This study evaluated the effects of using a universal adhesive and application of a flowable composite by the snow-plow technique on microleakage of Class II composite restorations in primary molars.

**Materials and Methods:** In this in vitro study, Class II cavities were prepared with their gingival margin at the cementoenamel junction in the proximal surfaces of 90 freshly extracted primary molars. The teeth were then assigned to 3 groups (n=30) for the application of a universal adhesive (Single Bond Universal) in total-etch and self-etch modes and a conventional etch-and-rinse adhesive (Single Bond 2). Each group was divided into 3 subgroups (n=10) for restoration without a flowable liner (control), application of a precured flowable liner, and using a flowable composite as liner by the snow-plow technique. After 1000 thermal cycles, the gingival margin microleakage was evaluated using the fluid filtration technique. Data were analyzed by two-way ANOVA and Tukey's test (alpha=0.05).

**Results:** Type of adhesive, unlike liner application (P=0.579), had a significant effect on microleakage (P=0.01). Application of universal adhesive (whether in self-etch or total-etch mode) resulted in less microleakage than the conventional etch-and-rinse adhesive. There was no statistically significant difference between the two application modes of the universal adhesive (P>0.05).

**Conclusion:** Application of Single Bond universal adhesive for composite restoration of primary molars may improve the marginal seal and decrease microleakage.

**Keywords:** Composite Resins; Dental Bonding; Tooth, Deciduous; Dental Leakage

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## INTRODUCTION

Recent improvements in mechanical properties of composite resins and increased esthetic demands of patients have made composite resins the first choice for restoration of anterior and posterior teeth, especially in children [1]. Some of the advantages of composite resins include being mercury-free, low thermal conductivity compared to amalgam, the ability to bond to tooth structure, conservation of tooth structure, and excellent esthetic results [1,2]. However, polymerization shrinkage is still one of the most important drawbacks of composite resins. The magnitude of polymerization shrinkage depends on the type of composite resin, and may vary from 1.7% to 2.6% [1]. This shrinkage may produce 5-15 MPa contraction stress between the composite material and

tooth structure that can lead to formation of marginal gap, microleakage, secondary caries, postoperative tooth hypersensitivity, and restoration failure [1,3-5].

Different techniques have been suggested to minimize the adverse effects of polymerization shrinkage of composite materials and improve their marginal adaptation, such as the incremental application technique [1,6,7], modifications in the light curing techniques (soft start, dual curing, ramp curing, and delayed curing) [1], use of self-cure composites [8], and application of low-shrinkage methacrylate monomers such as silorane [9].

Application of stress-absorbing liners is one suggested method to decrease the side effects of contraction stresses. Some materials, such as glass ionomers or flowable composites have a low modulus of elasticity, and therefore, can absorb the contraction stress of composite and prevent marginal gap formation [4,7,10-12]. The optimal efficacy of these techniques for reduction of microleakage at the dentinal margin of restorations has been previously documented [13-16]. However, some studies showed that application of pre-cured flowable composite resins as liner did not enhance the quality of marginal seal [17-19]. Recently, a meta-analysis evaluated in vitro and in vivo studies to assess the efficacy of application of cured flowable composite as a liner for reduction of microleakage of composite restorations. The results indicated that application of cured flowable composite did not decrease the microleakage or improve the marginal seal, neither in vitro nor in vivo [20].

The snow-plow technique is another method for the application of flowable composite, which consists of the application of uncured flowable composite under conventional composite, and curing of both at the same time [11]. There is little evidence in the literature supporting the efficacy of this technique for improving the marginal seal of restorations [12,17].

It is noteworthy that an important factor that may affect the quality of marginal seal and microleakage is the type of adhesive system used for composite restorations [21,22]. Although three-step etch-and-rinse adhesives are the gold standard for restoration bonding [23], their application is time-consuming and technique-sensitive, especially when used for children [10]. The chairside time is a critical factor in pediatric dentistry for patient management. Self-etch adhesives have fewer clinical steps and less technical sensitivity in comparison with etch-and-rinse adhesives [24]; thus, they appear to be more applicable for children. Recently, a new type of adhesive known as universal or multi-mode adhesive was introduced to the market. These adhesives can be used in self-etch or etch-and-rinse (total-etch) mode [25,26]. Different studies have evaluated the bonding efficacy of universal adhesives in etch-and-rinse and self-etch modes in primary teeth [ref]. Lenzi et al. [27] suggested universal adhesives as a suitable alternative to two-step etch-and-rinse adhesives for primary teeth. However, there is no information in the literature on the effect of universal adhesives on the microleakage of composite restorations in primary teeth. Thus, the aim of the current study was to evaluate the effect of a universal and an etch-and-rinse adhesive and application of liner by the snow-plow technique on the microleakage of composite restorations in primary teeth. The first null hypothesis of this study was that different adhesives would not affect the microleakage of composite restorations in primary teeth. The second null hypothesis was that the application of flowable composite as a liner (snow-plow technique or cured before the application of conventional composite) would have no significant effect on the microleakage of composite restorations.

## MATERIALS AND METHODS

This in vitro study was approved by the Ethics Committee of Mashhad University of Medical sciences (ethical code: IR.mums.sd.REC.1394.90). The materials used in this study are listed in Table 1.

**Table 1.** Materials used in this study

| Composition | Manufacturer | Product |
|---|---|---|
| **BisGMA, HEMA, dimethacrylates, ethanol, water, a novel photo-initiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids** | 3M Dental Products, St Paul, MN, USA | Single Bond 2 Adhesive |
| **HEMA, MDP, dimethacrylate resin, photo-initiator system, methacrylate modified polyalkenoic acid copolymer, filler, water, ethanol, silane** | 3M Dental Products, St Paul, MN, USA | Singlebond™ Universal Adhesive |
| **BISGMA, UDMA, TEGDMA, BISEMA Fillers: Nanoparticles (silica: 20nm, zirconia: 4–11nm, agglomerate of 0.6–1µm)** | 3M Dental Products, St Paul, MN, USA | Filtek Z350 XT |
| **BISGMA, UDMA, TEGDMA, BISEMA Fillers: Nanoparticles (silica: 20nm, zirconia: 4–11nm, agglomerate of 0.6–1µm)** | 3M Dental Products, St Paul, MN, USA | Filtek Z350 XT flowable |

Ninety freshly extracted primary molar teeth, with at least one non-carious proximal surface, were debrided and disinfected with 0.5% chlorine-T solution and were then stored in saline, which was refreshed weekly. Standard Class II cavities were prepared measuring 2mm in buccolingual width and 1mm in depth. The position of the gingival wall was at the cementoenamel junction. The dimensions of the cavities were measured by a periodontal probe (Hu-Friedy, Usa). The cavities were then prepared with a sharp diamond fissure bur (Sun Shine, Dental Burs, CA, USA) and a high-speed handpiece (NSK Panamax 2, Japan) under water spray. The bur was replaced after preparation of 10 cavities. To assess the gingival microleakage, the dentin of the axiogingival line angle was removed by a needle diamond bur (Sun Shine, Dental Burs, CA, USA) until the pulp chamber was exposed; accordingly, the gingival microleakage pathway was prepared. Wax was applied in the prepared axial hole to seal the cavity. After completion of the restorative procedure, the wax was removed.

The teeth were then divided into 3 main groups of 30 each, using computer-generated random numbers:

***Group 1:*** Application of single bond universal (total-etch mode)

***Group 2:*** Application of single bond universal (self-etch mode)

***Group 3:*** application of conventional etch-and-rinse adhesive (single bond 2)

In groups 1 and 3, the enamel and dentin surfaces were etched with 35% phosphoric acid etching gel (Ultra-dent Production Inc., South Jordan, Utah, USA) for 30 and 15 seconds, respectively, rinsed with distilled water, and air dried. The adhesive systems were applied according to the manufacturers' instructions, and light-cured (Blue Phase C8; Ivoclar Vivadent; Schaan, Lichtenstein) with 600mW/cm$^2$ energy density for 20 seconds.

All teeth in each group were subdivided into 3 subgroups of 10, based on the restorative technique used: restoration without using a liner (control), application of flowable composite as liner (Filtek Z350 XT flowable, 3M ESPE, ST.Paul, USA) by the snow-plow technique, and use of flowable composite (Filtek Z350 XT flowable,3M ESPE, ST.Paul, USA) that was precured before the application of conventional composite (Fig 1).

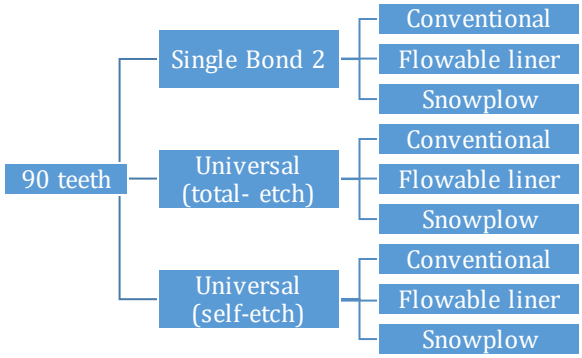


**Fig 1.** Experimental study groups

In all teeth, a Tofflemire matrix band (Termex, South Jordan, Utah) was adapted to the tooth to prevent proximal overhang. In the conventional method, the cavity was

restored with conventional composite (Filtek Z350 XT, 3M ESPE, ST.Paul, USA by the incremental application technique. Each increment was light-cured with a light intensity of 600mW/cm$^2$ for 40 seconds.

In the precured flowable composite subgroup, one layer of flowable composite (Filtek Z350 XT flowable, 3M ESPE, ST.Paul, USA) with 1 mm thickness was applied over the gingival wall of the cavity. The thickness of the flowable liner was measured with a periodontal probe. This flowable layer was light-cured for 40 seconds; then, the restoration was completed similar to the conventional subgroup.

In the snow-plow subgroup, a thin layer of flowable composite (Filtek Z350 XT flowable, 3M ESPE, ST.Paul, USA) was applied on the gingival wall, and the first increment of the conventional composite was applied over the uncured flowable composite, and co-curing was performed for 40 seconds. The procedure was completed similar to the previous subgroup. All preparations and restorative procedures were performed by one operator.

All teeth were thermocycled for 1000 cycles (5°C to 55°C, dwell time: 30 seconds, transfer time: 15 seconds).

The fluid filtration technique was used for evaluation of microleakage of restorations at the gingival floor. In this technique, displacement of bubble in the pipette indicates microleakage. A plastic tube (2mm diameter and 2cm height) was attached to the gingival floor (at the location of the wax). First, the plastic tube was attached to the positive control group (restored teeth without any adhesive system), and rapid movement of the bubble was monitored. Then, the plastic tube was attached to the negative control group (intact teeth), and no bubble movement was observed after 10 minutes. A 10-megapixel digital camera (Powershot G 11, Canon, Tokyo, Japan) and Adobe Photoshop 7.0 software (Adobe Systems Inc., San Jose, CA, USA) were used to evaluate the bubble movement (Fig 2). The volume of the fluid passing through the tube was measured in µL/minute.

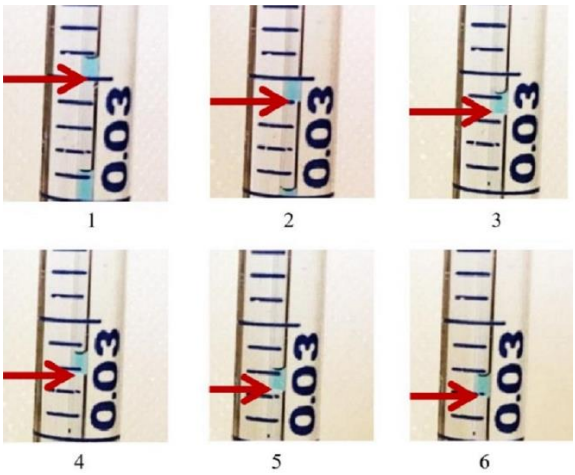


**Fig 2.** Bubble movement in the tube in the fluid filtration technique

Data were analyzed by the Kolmogorov-Smirnov test, two-way ANOVA (application of liner and type of adhesive system) and Tukey's post-hoc test with a significance level of 0.05.

## RESULTS

The microleakage values of the experimental groups are presented in Table 2.

**Table 2.** Mean microleakage values in the experimental groups (n=10)

| Liner | Bonding | Mean± Standard Deviation |
|---|---|---|
| **Without liner** | SB[a] | 0.32 ± 0.209 |
| | UT[b] | 0.15 ± 0.143 |
| | US[c] | 0.28 ± 0.193 |
| | Total | 0.25 ± 0.192 |
| **Precured liner** | SB[a] | 0.43 ± 0.205 |
| | UT[b] | 0.21 ± 0.172 |
| | US[c] | 0.13 ± 0.105 |
| | Total | 0.25 ± 0.206 |
| **Snow-plow** | SB[a] | 0.27 ± 0.216 |
| | UT[b] | 0.26 ± 0.134 |
| | US[c] | 0.11 ± 0.128 |
| | Total | 0.21 ± 0.175 |

[a] Single Bond 2; [b] Universal adhesive in total-etch mode; [c] Universal adhesive in self-etch mode

Normal distribution of data was confirmed by the Kolmogorov-Smirnov test (P>0.05). Two-way ANOVA indicated that the application of liner had no statistically significant effect on

microleakage (P=0.579). However, type of adhesive system significantly affected the microleakage (P=0.01). Also, the interaction effect of the two variables (liner and type of adhesive) was significant (P=0.030, Fig 3, Table 3). The Tukey's post-hoc test demonstrated that there was a significant difference between the universal adhesive in self-etch (P=0.001) and total-etch (P=0.01) modes and the etch-and-rinse adhesive (Table 4). But there was no significant difference between the two application modes of universal adhesive in microleakage (P=0.735).

In the flowable liner group, a significant difference was only observed between universal adhesive in self-etch mode and total-etch adhesive group (P=0.007). However, no significant difference was found between other adhesive groups (P>0.05). In the snow-plow technique, application of universal adhesive in the self-etch mode significantly reduced the microleakage in comparison with the total-etch mode (P=0.022) or universal adhesive in total-etch mode (P=0.041). In the conventional group, use of different adhesives had no significant effect on microleakage (P=0.06).

**Fig. 3.** Microleakage of different adhesives and techniques

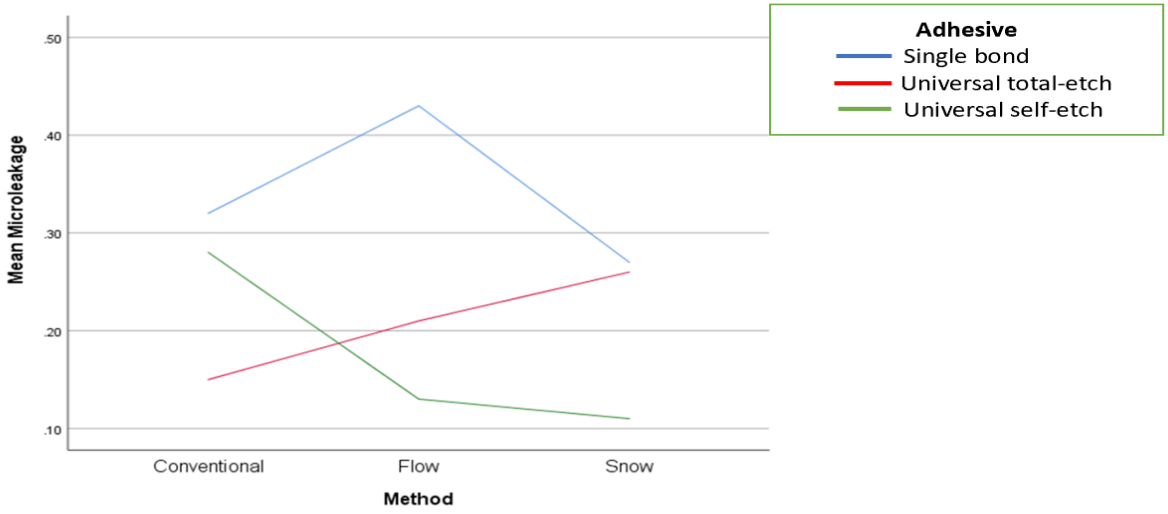


**Table 3.** Two-way ANOVA: liner application and adhesive system effects on microleakage

| Source | Type III Sum of Squares | df | Mean Square | F | P value |
|---|---|---|---|---|---|
| **Liner** | 0.03 | 2 | 0.01 | 0.55 | 0.579 |
| **Adhesive** | 0.46 | 2 | 0.23 | 7.86 | 0.001 |
| **Liner × Adhesive** | 0.33 | 4 | 0.08 | 2.82 | 0.030 |

**Table 4.** Tukey's post-hoc test results: microleakage comparison between adhesive systems

| Adhesive (I) | (J) | Mean Difference (I-J) | Standard Error | P value | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| **SB[a]** | UT[b] | 0.13* | 0.04 | 0.010 | 0.02 | 0.23 |
| | US[c] | 0.16* | 0.04 | 0.001 | 0.06 | 0.27 |
| **UT** | SB | -0.13* | 0.04 | 0.010 | -0.23 | -0.02 |
| | US | 0.03 | 0.04 | 0.735 | -0.07 | 0.13 |
| **US** | SB | -0.16* | 0.04 | 0.001 | -0.27 | -0.06 |
| | UT | -0.03 | 0.04 | 0.735 | -0.13 | 0.07 |

Based on observed means; The error term is Mean Square (Error) = 0.030; *The mean difference is significant at 0.05 level; [a] Single Bond 2; [b] Universal adhesive in total-etch mode; [c] Universal adhesive in self-etch mode.

## DISCUSSION

This study evaluated the effect of liner application and two different adhesives on the microleakage of Class II composite restorations in primary teeth. According to the results, the first null hypothesis was rejected because the type of adhesive system affected the microleakage value. However, the second null hypothesis was accepted since the application of liner (snow-plow or pre-cured flowable) had no significant effect on microleakage.

In the present study, application of Single Bond 2 increased the microleakage values significantly more than the single bond universal adhesive (self-etch and total-etch modes). However, there was no statistically significant difference between different application modes of the universal adhesive. Previous study concluded that mild self-etch adhesives can serve as the gold standard for bonding to dentin structure and can offer better adhesion to dentin in comparison with strong or moderate self-etch adhesive systems [10]. The pH of Single Bond Universal adhesive is above two; thus, it is considered a mild self-etch adhesive. In agreement with the present results, Thanaratikul et al. [28] indicated that Scotchbond Universal had a higher bond strength to primary dentin in comparison with Single Bond 2, and also no significant difference was found between self-etch and total-etch application modes of this universal adhesive. However, Rosa et al, [29] in a meta-analysis on bond strength of universal adhesive systems concluded that application of etchant on dentin may improve the bond strength of only ultra-mild universal adhesives.

One advantage of self-etch adhesives is that they are less technique sensitive and time-consuming which are both critical in pediatric dentistry. Pitchika et al. [30] reported that use of self-etch adhesive systems can improve the success rate of composite restorations of primary teeth in high-risk populations. Muñoz et al. [26] concluded that the performance of universal adhesives is material-dependent because of different compositions and pH values of these adhesive systems. Universal adhesives can be categorized as moderate, mild, or ultra-mild adhesives according to their pH. Different acidic monomers such as 10-MDP, 4-MET, or PENTA are used in composition of these adhesives; also, they may contain saline which may affect their bonding efficacy [29].

It should be taken into consideration that Scotchbond Universal adhesive contains 10-MDP. This monomer can form a stable nano-layer that can decrease hydrolytic degradation of the bond and improve bonding stability [26]. On the other hand, presence of polyalkenoic acid copolymer in this adhesive system may impair the bond of 10-MDP to dentin by competing with it through binding to calcium in hydroxyapatite [31]. Furthermore, this copolymer may interfere with monomer approximation, which is an important factor in the polymerization process [31].

In the current study, the microleakage of the universal adhesive (self-etch and total-etch modes) was significantly lower than that of the etch-and-rinse adhesive (Single Bond 2). In contrast to this finding, Karaman et al, [32] and Gupta et al. [33] found no significant difference between the microleakage scores of an etch-and-rinse adhesive (Single Bond 2) and a universal adhesive (single bond universal) at the gingival margin of Class V restorations of permanent teeth. Structural differences between the primary and permanent dentin including less mineralization and density of primary dentin compared to permanent dentin [34] may explain the controversy between the present results and those of the abovementioned studies.

Flowable composites have a lower filler content and can act as a stress-releasing layer to decrease polymerization shrinkage stresses of conventional composites; therefore, they may improve the marginal seal and decrease microleakage. In the present study, application of flowable composite as a liner, whether in precured form or by the snow-plow technique with an overlying composite, had no significant effect on microleakage. This result was in line with the findings of Gungor et al, [34] who found that application of liners (flowable composite or glass ionomer) had no significant effect on microleakage at the gingival margin of Class II composite restorations in primary teeth.

It should be noted that polymerization shrinkage of flowable composites is three times more than that of conventional composites [10]. Boruziniat et al, [20] in a meta-analysis concluded that application of flowable composite as a liner, which is cured before placement of the overlying composite, cannot decrease the microleakage or improve clinical efficiency of composite restorations.

Reddy et al. [35] found that application of an ultrathin (0.5 to 1mm) layer of flowable composite by the snow-plow technique can improve the marginal seal and decrease the microleakage of Class II composite restorations in permanent molars. They explained that the flowable composite may stretch or transform to relieve the polymerization shrinkage stresses of the overlaying composite in the snow-plow technique. In contrast, Sensi et al. [36] concluded that the use of snow-plow technique may even increase the microleakage at the gingival margin compared to the application of precured flowable composite. Nematollahi et al, [37] and Bore Gowda et al, [38] also demonstrated the same results and explained that the uncured flowable composites may penetrate into the main bulk of the overlaying composite and increase its resin content when applied in the snow-plow technique. Thus, it may increase the polymerization shrinkage and subsequently the microleakage. Furthermore, the polymerization stress of the overlying composite can pull the uncured underlying flowable composite away from the cavity wall, and disrupt its adaptation [12].

Particular attention should be paid to the methods used for microleakage evaluation when comparing the results of different studies. In the present study, in contrast to the aforementioned studies [36-38], the fluid filtration technique was used for evaluation of microleakage. Nikhil et al. [39] showed that there was no significant difference between the results of the fluid filtration and dye penetration techniques. Jafari and Jafari [40] in their systematic review demonstrated that the results obtained from different microleakage evaluation methods cannot be compared.

Only one universal adhesive was evaluated in the present study, which was a limitation; therefore, the obtained results may not be generalizable to all universal adhesive systems. Further studies are recommended on the microleakage of universal adhesive systems with different compositions. Moreover, clinical studies are required on the effect of flowable liner and universal adhesives on the success rate of composite restorations.

## CONCLUSION

In this in vitro study, application of a flowable composite as a liner (precured or snow-plow with overlying composite) had no significant effect on the microleakage of Class II composite restorations in primary teeth. Application of single bond universal adhesive (self-etch or total-etch mode) significantly decreased the microleakage.

## CONFLICT OF INTEREST STATEMENT

None declared.

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