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Comparison of Dentinal Microleakage of Class II Composite Restorations Using Universal Bonding: Self-Etch and Selective-Etch of Enamel, with and without Liner

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ABSTRACT

Background and Objective: Microleakage is one of the most important causes of failure in restoration and secondary caries. This study was conducted in order to compare dentinal microleakage of class II composite restorations using Universal Dental Adhesive, with and without liner.

Methods: In this laboratory study, two Class II cavities were prepared in the mesial and distal surfaces of 48 healthy premolar teeth. Then, the samples were divided into 6 groups of 8 according to the application method of Single Bond Universal adhesive and liner: selective etching of enamel (SEE), self-etch (SE) technique, SEE technique and resin-modified glass-ionomer (RMGI) liner, SE technique and RMGI Liner, SEE technique and Flow Liner, and SE technique and Flow Liner. Restoration was done with Filtek Z250 composite. Microleakage was evaluated and compared using 2% fuchsine based on intensity 0 to 3.

Findings: In the SEE group, 56.2% of restorations did not have microleakage. 31.2% had grade 3 microleakage and 12.5% had grade 1 microleakage. However, in the SEE+RMGI group, 81.25% and the SEE+Flow group, 81.2% of the restorations had no microleakage. In the SE group, 18.7% of restorations showed zero microleakage, 50% showed grade 3 microleakage, and 31.2% showed grade 2 microleakage. However, in the SE+RMGI group, 81.25% and in the SE+Flow group, 93.7% of the restorations did not have microleakage. The distribution of dentinal microleakage intensity between SEE and SE methods (p=0.067) and between SEE+RMGI and SEE+Flow groups (p=0.194) was not significant. However, in the SE+Flow and SE+RMGI groups, this difference was significant (p<0.001).

Conclusion: The results of this study showed that in the method of using a liner with Universal adhesive, dentinal microleakage in class II composite restoration decreased.

Keywords: *Composite Resin, Bonding Agents, Self-Etch, Dental Liner, Leakage.*

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Introduction

Nowadays, composite resins are widely used to restore posterior teeth (1). Despite various advantages, an important problem of composites is shrinkage caused by polymerization (2.6-7.1%), which leads to microleakage by creating stress between the restoration spot and the tooth (2). Microleakage increases tooth sensitivity, secondary caries and pulp damage. Studies have introduced different methods to reduce microleakage, which include incremental technique, reducing the speed of composite polymerization, and placing a liner with high elasticity under the composite (3).

In total-etch adhesives, in the etching stage, the smear layer is removed and the collagen fibers of the dentine are exposed by using phosphoric acid gel on the enamel and dentin. In the next step, primer and bonding are placed separately or combined in a bottle on the etched surface (4). The main problem of these adhesives is the risk of collagen fibrils collapse during drying of demineralized dentin, which reduces the strength of the bond due to the incomplete penetration of resin monomers. Self-etch adhesives do not have a separate etching step, and etching and priming are done simultaneously in enamel and dentin, and the entire depth of the demineralized dentin is saturated with resin monomers (5). An obvious disadvantage of these adhesives is reduced effective bond to enamel due to their low acidity. For this reason, Selective Enamel Etch (SEE) is recommended in cavities with enamel margins. This technique combines the advantages of the total etch system in the enamel margin and the advantages of the SE system in the dentin (5, 6). According to the manufacturer's instructions, Universal adhesives can be used with three methods: total etch, SE or SEE, and the bond strength does not change with the amount of dentin moisture or the bonding method (7).

Microleakage of bonded composite restorations with universal systems has been investigated in several studies (8-13). In the study by Motevaselian et al. and Gupta et al., there was no significant difference in dentinal microleakage of universal adhesive in self-etch and total-etch (2, 12), but some studies have reported different dentinal microleakage of universal adhesive in self-etch and total-etch methods (10, 11, 13).

Considering that there is little information about the microleakage of composite restorations bonded with universal adhesive and the effect of using different liners on it, this study was designed and performed to compare the dentinal microleakage of class II composite restoration bonded with universal adhesive using two self-etch and selective-etch methods with and without Flow and RMGI composite liners.

Methods

Preparation of teeth: This laboratory study was carried out after obtaining approval from the ethics committee of Babol University of Medical Sciences with ethics code IR.MUBABOL.REC.1397.017. According to the study of Kasraei et al. (13), the sample size was eight teeth in each group and a total of 48 teeth. The examined samples were 48 healthy premolar teeth without caries and cracks, which were extracted for orthodontic treatment no more than three months ago. After cleaning with a scaling instrument, the teeth were disinfected in 1% chloramine T solution (Sigma-Aldrich, St Louis, MA, USA) for 24 hours and then kept in physiological serum until the start of the experiment. On the mesial and distal surfaces of each tooth, Class II cavities with a buccolingual width of 3 mm and an axial depth of 1.5 mm were carved in the gingival wall. The gingival margin of the cavity was 1 mm below the CEJ. Tooth carving was done with cylinder diamond burs size 12 (Jota, Switzerland) and turbine (Japan, NSK) with air cooling. With this method, 96 class II cavities were prepared in 48 teeth. All cavity preparation and restoration procedures were performed by one person. Then the teeth were randomly divided into 6 groups of 8 (2). Then the cavities of each group were prepared as follows.

Group 1: Universal adhesive with selective enamel etching technique without the application of liner (SEE): enamel margins were etched using 38% phosphoric acid gel (Pulpdent corporation, Watertown, MA, USA Etch-Rite TM) for 15 seconds, then washed for 20 seconds and dried slowly. Then, 3M™ Single Bond Universal Adhesive (3M ESPE, St. Paul, MN USA) was placed on the cavity surfaces for 20 seconds and dried for 5 seconds (Table 1).

Then it was light-cured for 10 seconds using LED-Valo device (Ultradent, South Jordan, USA) with an intensity of 1000 mW/cm2. The light intensity of the device after each radiation was measured by a radiometer device (Kerr, Orange, CA, USA) to control the output of the device.

Table 1. The list and chemical composition of materials used in this study

Materials	LOT No.	Chemical composition	Manufacturer
RMG, LC Fuji II	1704031	Powder: fluoroaluminosilicate glass Liquid: copolymer of acrylic and maleic acids, HEMA, tartaric acid, water, chemical initiators	A spoonful of powder with two drops of liquid is poured on the slab, then the powder is divided into two equal parts. The first part is mixed with the liquid for 15 seconds, then the rest of the powder is added and mixed for 10 seconds.
Single Bond Universal	661544	MDP, phosphate monomer, HEMA, DMA, polyalkenoic acid copolymer, Filler, Ethanol, Water, Initiators, Silane	
Filtek, Z350	N900873	TEGDMA, Bis EMA, ytterbium trifluoride filler, silica filler, ZrO2	
Filtek Z250	N901906	Bis GMA, UDMA, Bis EMA, ZrO2, SiO2	
Etch-Rite 38% phosphoric acid	170809	38% phosphoric acid gel, amorphous fumed silica	

Abbreviations: HEMA= 2-hydroxy-ethyl-methacrylate, MDP= Methacryloyloxydecyl dihydrogen phosphate, DMA= Dimethacrylate resins, TEGDMA= Triethylene glycol dimethacrylate, Bis EMA= ethyl methacrylate, Bis GMA= bisphenol A-glycidyl methacrylate, UDMA= urethane dimethacrylate.

Group 2: Universal adhesive with self-etch technique without using liner (SE): UB adhesive was placed on the walls of the cavity for 20 seconds and dried for 5 seconds with air and then cured for 10 seconds.

Group 3: Universal adhesive with selective enamel etching technique and RMGI liner (SEE+RMGI): First, resin-modified glass ionomer (Fuji II LC, GC corporation, Japan) was mixed according to the manufacturer's instructions. For this purpose, a spoonful of powder with two drops of liquid was poured on the slab, then the powder was divided into two equal parts. The first part was mixed with liquid for 15 seconds, then the rest of the powder was added and mixed for 10 seconds. A thin layer of it with a thickness of 0.5-1 mm was placed on the axial and gingival wall at a distance from the gingival margin. The thickness of the RMGI layer from the axiopulpal line angle to the middle of the axial wall and also on the gingival floor to near the gingival margin was reduced to zero thickness and light cured for 20 seconds. Then the bonding and curing steps were performed similar to group one.

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Group 4: Universal adhesive with self-etch technique and RMGI liner (SE+RMGI): Liner placement steps were similar to group three and bonding and curing steps were similar to group two.

Group 5: Universal adhesive with enamel selective etch technique and Flow composite liner (SEE+Flow): the same bonding steps were performed as group 1 and before restoration with composite resin, a thin layer of 0.5-1 mm Flow composite (Filtek Flow Z350, 3M ESPE, St.Paul, MN, USA) was placed on the axial and gingival wall at a distance from the gingival margin and with the conditions mentioned for RMGI and light cured for 20 seconds.

Group 6: Universal adhesive with self-etch technique and Flow composite liner (SE+Flow): Liner placement steps were similar to group five and bonding and curing steps were similar to group two.

After the above steps, Tofflemire Type Matrix Bands were closed on the teeth of each group and the cavity was filled with Filtek Z250 composite resin (3M ESPE, St. Paul, MN, USA) layer by layer. The first layer was placed horizontally with a thickness of one millimeter and cured for 40 seconds. In the rest of the cavity, 2 mm composite layers were placed buccally or lingually and cured for 20 seconds. All teeth were placed in physiological serum in an incubator (IP60, LTE Scientific Ltd, United Kingdom) at 37°C for 24 hours. Then, thermocycling (Nemo, Mashad, Iran) of the samples was performed with a thousand cycles at a temperature of 5-55 °C with a rest time of 30 seconds (11). After this step, the entire surface of the samples, except for 1 mm around the restoration margins, was covered with 2 layers of nail polish, and the apex of the teeth was sealed with wax. In order to measure microleakage, the dye penetration method (24 hours immersion in 2% fuchsine at 37°C) was used. After washing the samples, the teeth were divided into two halves using a diamond disc (Micron T201 A) in a cutting machine (Nemo, Mashad, Iran) mesially/distally from the middle of the restoration. During the cutting process, the flow of water was used both as a coolant and as a cleaner of the debris caused by cutting. The cutting area of the samples was observed under a stereomicroscope (Dewinter, Milano, Italy) with a magnification of 40 to check the amount of microleakage. The degree of microleakage in the gingival floor was graded as follows: zero: no dye penetration, one: dye penetration up to half of the gingival floor, two: dye penetration in the entire gingival floor without involvement of the axial wall, three: dye penetration in the entire gingival floor with axial wall involvement (2).

The data were transferred to SPSS 17 software. For the two variables of etch technique and liner type, the median index was reported separately. Then, Whitney-Mann analysis was performed for two variables. For overall comparison, Kruskal-Wallis analysis was performed and if the difference was significant, pairwise comparison was used and $p<0.05$ was considered significant.

Results

Among the studied groups, the intensity of microleakage was the highest in the SE group (50%) and the lowest in the SEE+RMGI, SE+Flow and SEE+Flow groups (0%) (Table 2). The SE+Flow group had the highest number without microleakage (zero intensity) (15 cases) and the number of samples with microleakage with intensity of 2 and 3 was zero (Figures 1 to 4). Meanwhile, no significant difference was seen in the amount of microleakage in SE and SEE groups. But the SE group was significantly different from the other 4 groups (median=2.5, $p<0.001$). Comparing the groups with and without liners, the color penetration was significantly higher in the groups without liners ($p<0.001$), but the difference in microleakage between the groups with Flow and RMGI composite liners was not statistically significant. There was no significant difference in the types of liners between the groups that were repaired with the SEE technique, but there was a significant difference between the groups that were repaired with the SE technique ($p<0.001$).

Table 2. Distribution of the frequency of microleakage (percentage) in the dentinal margin of different groups

Microleak rate Groups	Zero number(%)	One number(%)	Two number(%)	Three number(%)	Median	p-value
SEE	9(56.25)	2(12.5)	0(0)	5(31.25)	0^{ab}	<0.001
SE	3(18.75)	0(0)	5(31.25)	8(50)	2.5^{a}	<0.001
SEE+RMGI	11(68.75)	3(18.75)	2(12.5)	0(0)	0^{b}	<0.001
SE+RMGI	13(81.25)	0(0)	2(12.5)	1(6.25)	0^{b}	<0.001
SEE+Flow	13(81.25)	1(6.25)	2(12.5)	0(0)	0^{b}	<0.001
SE+Flow	15(93.75)	1(6.25)	0 (0)	0(0)	0^{b}	<0.001

[*]Different lowercase letters in the middle column indicate the existence of a significant difference at the α=0.05 level.

Figure 1. Grade 0 microleakage

Figure 2. Grade 1 microleakage

Figure 3. Grade 2 microleakage

Figure 4. Grade 3 microleakage

Discussion

The results of the present study showed that the rate of microleakage of dentinal margins in groups with liners is significantly lower than the group without SE liner, although no significant difference was observed in the dentinal of microleakage of dentinal margins in SE and SEE groups.

Microleakage is the main factor affecting the durability of composite restorations (14). The adhesive layer plays an important role as the connecting layer of composite restorations to the tooth structure.

Universal adhesives can be applied with three methods, ER, SE or SEE, according to the manufacturer's instructions. For this reason, in this research, two applied adhesive methods, Single Bond Universal Adhesive, SE, and SEE, were investigated and compared on the grade of microleakage of dentinal margins in Class II cavities.

Single Bond Universal Adhesive with pH=2.7 (mild) with partial demineralization of dentin leads to the remaining of some hydroxyapatite crystals around the collagen fibers and the formation of a chemical bond. On the other hand, due to the lack of complete removal of the smear plug from the dentinal tubules, the resulting hybrid layer is also thin (2, 8). According to the claim of the Single Bond Universal adhesive manufacturer, it contains the phosphate monomer MDP (Methacryloyloxydecyl dihydrogen phosphate) and polyalkenoic acid VitreBond copolymer, which can form a chemical bond with cations such as calcium and improve the bond between the hybrid layer and the tooth (9). In the study of Motevaselian et al. and Kermanshah et al., the use of universal adhesive based on self-adhesive method showed less microleakage compared to total etching, although this difference was not significant (2, 9). Exposed dentinal collagens in the total etch method are prone to hydrolytic and enzymatic degradation and microleakage, while in the self-etch technique, the remaining hydroxyapatite crystals around the collagen fibers form an ionic bond with the MDP present in the universal adhesives, and this stabilizes the bond and microleakage is reduced (9).

The studies of Perdigão et al. showed that the marginal integrity of composite restorations in the ER and SEE methods is higher than the SE method (15). In the SE technique, the amount of acidity is less and as a result, the enamel etching depth is less, which can be the cause of marginal destruction (8), but in the SEE technique, with the improvement of the marginal integrity of the enamel, marginal microleakage is also reduced (9). According to the results of our study, separate etching of enamel before the application of universal adhesive reduced dentinal microleakage, but this reduction was not significant. Universal adhesive with chemical and micromechanical bonding effectively provides enamel marginal seal (16, 17). The SEE technique has been investigated in several studies, but there was no significant difference in terms of marginal seal compared to the SE technique (15, 18-20).

In the present study, there was a significant difference between the groups with and without liners. Groups without liners showed more microleakage in the dentinal margins. However, microleakage was not different between groups with RMGI liner and Flow composite. These results are in agreement with some previous studies (21-24). Liners are deformed under the influence of external forces due to their lower elasticity coefficient, and this quality can reduce the shrinkage stress of composite resins by 20-50% due to higher elasticity coefficient. In addition, the use of liners in restoration cavities leads to a reduction in the volume of composite and also C-Factor (22, 23). In the study of Arami et al., it is stated that the use of Flow composite liner under Class II composite restorations reduces microleakage in the dentinal margin (1). However, Kasraei et al. showed that RMGI significantly reduced microleakage compared to Flow composite (13). In our study, the placement of RMGI was done by probe, while placement of Flow composite was done by syringe. Syringe can reduce microleakage by improving the compatibility of Flow composite and cavity walls (21).

Among the limitations of this study was the qualitative assessment of microleaks, although several effective factors, including the conditions of collection and storage of samples, may make it difficult to compare the results with different studies. The high cost, the difficulty of cutting the teeth similarly can be considered as other limitations of conducting the study.

The present study was conducted in a laboratory manner, and for more detailed investigations, it is better to design and conduct another study in a clinical manner. It is also suggested that other types of universal adhesives be examined with ER, SE and SEE methods in terms of microleakage.

The present findings showed that there was no significant difference between SE and SEE adhesive universal application methods in terms of dentinal microleakage and the amount of microleakage was significantly reduced in groups with liners, but there was no significant difference between groups with composite Flow and RMGI liners in universal adhesive based on SE and SEE techniques.

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