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Research Paper: Investigation of Micro-leakage of Self-cured and Light-cured composite restorations using a universal bonding system

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ABSTRACT

Introduction: One-bottle light-cured adhesives systems have variable pH. In addition to ease of use, universal adhesives can be used in various restorations and different substrates. Due to the lack of studies, the purpose of this study was to compare the enamel and dentin micro-leakage of self-cure and light cure composite restorations using a universal bonding system.

Materials and Methods: The CL V cavities prepared on 60 bovine incisors (dimensions of 5 mm mesio-distal, 2 mm occluso-gingival and 1.5 mm in depth). Occlusal and gingival margins were 1mm above and below the CEJ. All Bond Universal bonding agent was applied to the cavities according to the manufacturer's instructions by selective etch method. The teeth randomly divided into group 1 which were restored with Master-Dent self-cure composite and group 2 restored with light cure AELITE All-Purpose composite. After thermocycling, the micro-leakage rates evaluated in two occlusal and gingival margins by stereomicroscope. The Mann-Whitney U test used to compare the micro-leakage ($P \leq 0.05$).

Results: The rate of micro-leakage at both gingival (dentin) ($p \leq 0.035$) and occlusal (enamel) ($P \leq 0.015$) margins in the self- cure composites were significantly higher than the light cure composites. In each group, gingival micro-leakage was also recorded higher than the occlusal (however, this difference was not statistically significant in the self-cure composite group) ($P = 0.474$).

Conclusion: According to the results, the All Bond Universal adhesive agent is not compatible with self-cure composite and can result in increased micro-leakage.

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Introduction

Increasing patient demand for more esthetic restorations has led the research toward tooth-colored restorations. In this regard, the resin-based composites are the most widely used ones (1). Due to their specific characteristics such as color, texture, luminosity, translucency, fluorescence properties, lack of mercury, thermal insulation and bonding to teeth feature with adhesives; the composites have numerous uses and applications in direct restorations (2, 3, 4). Dental adhesives have also undergone changes alongside composites and dramatic progress has been achieved in this regard (5). Adhesive systems should create a two-way bond between restorative materials on one hand and the dental tissue, on the other hand (6).

The main topic of this research focused on Universal Adhesives. These adhesives, which are often single-step (1-step), have simplified the bonding process. They can also be used for bonding with various types of materials, including a variety of indirect or direct restorations (self-cure / light-cure / dual-cure restorative materials).

These adhesives include a combination of hydrophilic monomers known as HEMA and hydrophobic monomers known as decandiol dimethacrylate / D3MA and BIS-GMA. These compounds allow the bonding between the wet surfaces of the tooth and the hydrophobic resin monomers of restorative materials (7, 8).

Universal adhesives can be used with three approaches:

Self-etching

Due to the presence of acidic phosphorylated monomers (MDP) and with no need for separate etching by phosphoric acid.

Enamel Selective Etch

Separate use of phosphoric acid on enamel and making stronger bond to it.

Total Etch

The use of phosphoric acid on enamel and dentin for 15 seconds with the presence of acidic monomers found in the adhesives. (9)

Bisco Company is one of the companies that manufacture this kind of adhesives, which has produced an adhesive known as All-Bond Universal. This adhesive is a light- cure bonding agent containing etchant, primer and bonding agents in one bottle. All-Bond Universal is an ethanol/water base adhesive for dentin and cut / uncut enamel. The manufacturer claimed that it is designed and capable of bonding to self- cure and light- cure composites. This adhesive can also be used with or without phosphoric acid (as an extra etching agent) (8).

The self- cure composites are still used in some cases of cavities where the access of light is limited such as the crowns substructure, bonded posts, cementation of inlays and onlays, and composite and ceramic crowns (9). There is a lack of compatibility between adhesives containing acidic resin monomers and self- cure composites, which leads to reduced shear bond strength between adhesive and composite and increased micro-leakage. The triple amines found in self-cure composites are deactivated with the low concentration of acidic resin monomer of the adhesive. By increasing the acidic monomers in the adhesive, its tendency for acid-base reaction with the amine component increases. This clinically implies incomplete polymerization between these two substances and reduced bond strength. To resolve this problem, many manufacturers have produced universal bonding agent with activators. Activator is a separate bottle containing substances such as sodium toluene sulfonate and ethanol, which resolves the bonding problem with the self-cure composites (10, 11). An important point, which requires further investigation, is the Bisco Company claim that proper bonding with self-cure composites does not need an activator. The reason for such a claim has mentioned being the mild pH of this adhesive (PH> 3) (11).

Despite the great importance of micro-leakage, which, if any, will lead to the creation of a gap between the restorative material and the tooth, causing secondary caries, bacterial penetration and stimulation of pulp, no research

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has been conducted so far to compare the micro-leakage between this adhesive and self / light cure composites even by the manufacturing company. Considering that the majority of papers have focused on examining the bond strength and micro-leakage between the adhesive and the dental tissue, we decided to evaluate the micro-leakage between the All-Bond Universal adhesive and the self-cure composite compared to the light-cure composite (9).

Materials and Methods

For this study, 60 healthy extracted bovine incisors without any decay and cracks were selected. After cleaning and removal of the tissue debris by scaler and disinfection (in 0.5% chloramine solution for 1 week), the teeth were kept in distilled water at room temperature.

The CL V cavities at labial surface were prepared by high-speed handpiece with #008 fissure diamond burr (Tizkavan, Iran) under a continuous air and water spray by a single operator (after preparing every 5 teeth, the bur was replaced). Cavities dimension were 5 mm mesio-distally, 2 mm occluso-gingivally, and 1.5 mm in depth, with the occlusal and gingival margins placed respectively 1 mm above and below the CEJ. The teeth were then randomly divided into two groups based on the type of composite used (The adhesive was the same in both groups).

In group 1, self-cure composite (Master-Dent) + All-Bond Universal and in group 2 AELITE Composite (Micro-Hybrid and light – cure, Bisco Company) + All-Bond Universal were used (Table1).

In both groups, the enamel margins of the cavity were etched with 35% phosphoric acid for 15 seconds, washed and dried. The shade of both composites was A2.

Table1: Composition and manufacturers of study materials

Materials	Commercial name	Compositions	Manufacturer
Chemical - Cure Composite	MASTER DENT	-Bis-GMA -TEGDMA	MASTER DENT, USA
Universal Microhybrid light- cure Composite	AELTE All-Purpose body	- Ethoxylated Bisphenol A -Dimethacrylated -Triethylen glycol Dimethacrylate -Glass filler -Amorphous silica	Bisco, Schaumburg, IL, USA
Bisco universal adhesive	All- Bond Universal	10MDP,HEMA,Bis-GMA, ethanol,photo initiator, water	Bisco, Schaumburg, IL, USA

Group 1

After CL V cavity preparation, the enamel margin of the cavity was etched with 35% phosphoric acid for 15 seconds. After washing and drying, the All-Bond Universal adhesive (Bisco Company) was used according to the manufacturer's instruction, which can be used in both self-etch and total-etch and selective-etch forms. Due to the advantage of reducing the clinical steps, selective etch method (separate etch of enamel & self-etch of dentin) was used. Finally, it was cured for 20 seconds with the light- cure device, Litex 680A (Dentamerica, USA). The light-cure device was previously calibrated to about 1200 mW/cm2 using Digi-Rate Device (Light Energy & Temperature).

The composite used in this group was self-cure composite manufactured by MASTER-DENT Company. According to the manufacturer instructions, equal amounts of base and catalyst were blended manually to achieve a uniform color. In order to prevent the creation of bubbles, two occluso-gingival increments were placed in the cavity with a condenser. After the completion of polymerization (5-10 mins), all specimens were stored in distilled water at room temperature for 24 hours.

Group 2

The composite used in this group was AELITE (Bisco, USA) of light-cure type.

To fill the cavity, oblique layering method was used, and the cavities were filled with three increments of composite (Each layer was 1 mm), and each layer was cured for 40 seconds and stored in distilled water for 24 hours.

Thermo cycling was performed in 500 thermal cycles in 55 °C and 5 °C (± 2) baths with 30 seconds dwell time in each bath and 15 seconds transfer time between the baths.

Subsequently, all dental surfaces were covered with two layers of nail polish up to 1 mm of the restoration margins and then samples placed in 0.5% Fuchsine solution for 24 hours. (To prepare 0.5% Fuchsine solution, 0.5 g of Fuchsine powder was mixed with 99.5 CC of distilled water).

After removing the samples from the Fuchsine solution, they were thoroughly washed with water and placed inside the plastic model filled with polyester.

The samples were then sectioned in a bucco-lingual direction at the centre of the restorations using a special blade and water coolant by the CNC machine (DELTA, Taoyuan technology, Taiwan) and the samples were divided into two mesio-distal halves.

The prepared sections were examined by KE Stereomicroscope (China Corporation) with a 30x magnification for measuring the dye penetration rate.

Dye penetration rate was determined in the occlusal and gingival margins and defined based on the following scale:

Score 0: With no dye penetration

Score 1: Dye penetration up to half of the depth or less in occlusal and gingival walls

Score 2: Dye penetration more than half of the depth without axial wall involvement

Score 3: Dye penetration with axial wall involvement

Each half was observed two times, and the larger number was considered in the evaluation.

Data were entered into SPSS Ver. 16 and The U and Mann-Whitney test was used for statistical analysis.

Results

In this study, 60 bovine incisor teeth were divided into two groups of 30 and evaluated for micro-leakage in light-cure and self-cure composite restorations. Therefore, we had two main groups:

Group 1: Samples restored with self-cure composite + All- Bond Universal

Group 2: Samples restored with light-cure composite + All- Bond Universal

Since the specimens were sectioned into two mesio-distal halves, each group had 60 specimens.

U and Mann - Whitney tests were used for statistical analysis.

Table 2 shows the distribution of micro-leakage in the gingival margin of groups 1 and 2.

According to Table 2, 65% of samples had no micro-leakage in group 1 (score 0), while in group 2, 76.7% showed no micro-leakage (Figure1). Performing the statistical test of $\alpha 2$ (chi-square) confirmed that the difference is significant. Thus, the micro-leakage was significantly lower in the gingival margin of the light- cure composite group ($p \leq 0.035$).

Table 2: Distribution of micro-leakage in the gingival margin of groups 1 and 2

Group	Group1		Group2		Total	
Score	Number	Percentage	Number	Percentage	Number	Percentage
1	39	65%	46	76.7%	85	70.8%
2	21	35%	11	18.3%	32	26.7%
3	0	0%	3	5%	3	2.5%
	60	100%	60	100%	120	100%

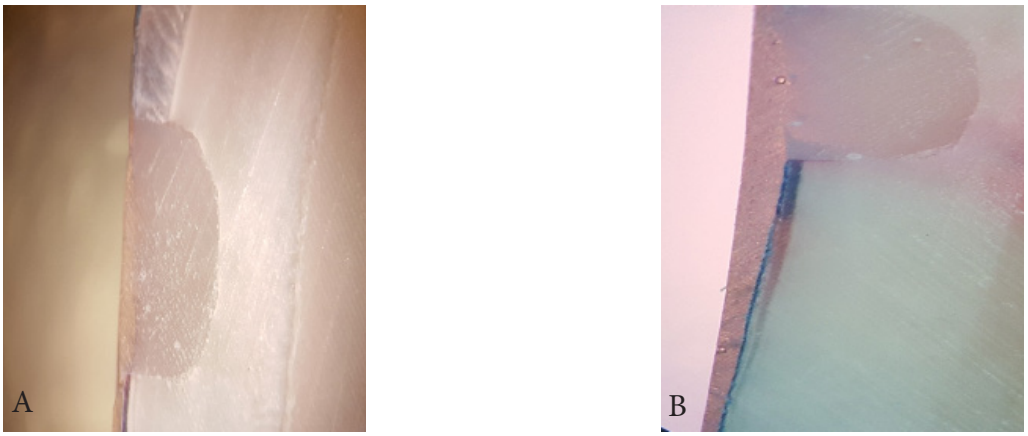

Figure 1. Stereomicroscope images of dye penetration at occlusal and gingival margins (A) score 0, (B) score 1

Table 3 shows the distribution of micro-leakage in the occlusal margin of two groups.

According to Table 4-2, 80% of the samples had no micro-leakage (score 0) in group 1, while 98.3% of group 2, had score 0. The difference was statistically significant. In other words, the micro-leakage of the occlusal margin in group 2 was also significantly lower than group 1 ($p \leq 0.015$).

Table 3: Distribution of micro-leakage in the occlusal margin of two groups

Group	Group 1		Group 2		Total	
Score	Number	Percentage	Number	Percentage	Number	Percentage
0	48	80%	59	98.3%	107	89.2%
1	10	16.7%	1	1.7%	11	9.2%
2	1	1.7%	0	0%	1	8%
3	1	1.7%	0	0%	1	8%
	60	100%	60	100%	120	100%

Table 4 shows the distribution of micro-leakage in the occlusal and gingival margins of group 1. According to table 4, no significant difference was found on micro-leakage rate between the occlusal and gingival margins in group 1 ($P = 0.474$).

Table 4: Distribution of micro-leakage in the occlusal and gingival margins of group 1

	Score 0	Score 1	Score 2	Score 3	Total
Givival margin	65%	35%	0%	0%	100%
Occlusal margin	80%	16.7%	1.7%	1.7%	100%

Table 5 shows the distribution of micro-leakage in the occlusal and gingival margins of group 2.

In group 2 or light-cure composite group, statistical analysis showed a significant difference between the micro-leakage rate of the occlusal and gingival margins. ($P \leq 0.0001$)

Based on available information, the gingival margin has a higher micro-leakage rate than the occlusal margin.

Table 5: Distribution of micro-leakage in the occlusal and gingival margins of group 2

	Score 0	Score 1	Score 2	Score 3	Total
Givival margin	76.7%	18.3%	0	5	100%
Occlusal margin	98.3%	1.7%	0	0	100%

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Discussion

Even though light-cure composites are nowadays one of the materials of choice for most restorations, their polymerization shrinkage is still a major problem. This shrinkage and the resulting stress can lead to the creation of a gap between the restorative material and the tooth, which is responsible for post-treatment sensitivity, recurrent caries and ultimately, failure of the restoration. Various methods have been proposed to reduce the polymerization shrinkage, like using a liner with a low elasticity coefficient, decreasing the polymerization rate using less light intensity at the beginning of polymerization, use of composite by an incremental approach, etc. (12). The micro-leakage test seems to be the most effective method for evaluating the quality of restorative material's sealing.

The micro-leakage appears to be more critical when considering the pulp stimulation is done by bacterial toxin rather than the toxicity of restorative materials. This marginal micro-leakage is especially challenging in the cervical Cl V lesions. Due to the heterogeneity of the dentin, the dentinal margin's seal at the Cl V restorations is much more complicated than the enamel margin. This sealing is the most important factor in determining the resistance to recurrent caries, post-repair sensitivity, marginal color change and pulpal damage. New adhesive systems are trying to simplify the clinical steps. Obviously, the bonding system with simpler clinical steps but a micro-leakage equivalent to the old systems would be the best choice for a dentist. Although no bonding system can prevent the micro-leakage completely, especially micro-leakage in the dentin margins (13).

The latest generation of adhesives recently introduced to the market is the single-bottle Universal Adhesives. These Adhesives have many advantages over previous generations, like being used by two self-etch and total-etch methods and with different substrates (14, 15, 16).

In this study, the micro-leakage rate of the AELITE light-cure composite (Bisco, micro-hybrid composite) and a self- cure composite restoration (Master-Dent) with a type of Universal adhesive, known as All-Bond Universal, were examined at two enamel and dentin margins.

To examine the micro-leakage rate, the Cl V cavities were prepared as a box to increase the C-Factor resulting from the polymerization shrinkage similar to the oral cavity. Also, all samples were thermo-cycled to get closer to clinical conditions. Due to the difference in the coefficient of thermal expansion of the tooth and the restorative material, the bonding area develops fatigue, which leads to the creation of gap and micro-leakage (17).

On the other hand, the compatibility between adhesive and composite is one of the most important clinical properties in selecting the materials (18).

As we know, there is an incompatibility between adhesives containing acidic resin monomers and the self-cure composites. With increased acidity of the adhesive, its affinity to acid-base reaction with the amine component of the self-cure and dual-cure composites would increase. This results in incomplete polymerization of these composites at the interface with the adhesive (10). One advantage of Universal adhesives is the use of them by two self-etching and total- etching methods. As a result of our researches and reviews, we decided to use selective enamel etch approach (19, 20).

In this study, we assumed that the micro-leakage of self-cure composite restorations by using a universal bonding system has no difference with the light-cure composite restorations (H0). According to the results of this study, the null hypothesis was rejected at both gingival and occlusal margins, and the micro-leakage rate in the self-cure composite group was recorded higher than the light-cure composite.

Also, in group 1 (self-cure composite) and group 2 (light-cure composite), the micro-leakage rate at the gingival margin was recorded higher than the occlusal margin. However, this finding was not statistically significant in group 1. The cause of increased micro-leakage at dentin surfaces (gingival margin) in both groups was due to the heterozygous nature of dentin tissue. Besides, dentin contains significant amounts of water, collagen type I and a network of tubules.

Tavangar SM, et al.Investigation of Micro-leakage of Self-cured and Light-cured composite restorations using a universal bonding system. Journal of Dentomaxillofacial Radiology, Pathology and Surgery. 2019; 8(2):31-38. http://dx.doi.org/

These tubules have more branches in the CEJ area and the root surface than the crown surface. Acid etching of these surfaces with phosphoric acid or acidic monomers found in the self-etch adhesives leads to a change in the morphology and chemical composition of these dentinal tubules, resulting in the hybrid layer changes. Consequently, the micro-leakage rate increases and a more unstable bond to dentin is formed (13, 21).

A study conducted by Mahmoud Bahari et al. showed that the use of the Universal adhesive (Bisco Universal adhesive / the same adhesive used in our article) by self-etch and total-etch on the surface of enamel or dentin have different rates of micro-leakage rate. At the enamel margins, the amount of micro-leakage by the total-etching method was recorded less than the self-etch approach. Conversely, At the dentinal margins, the self-etch method had significantly less micro-leakage compared with the total-etch method, and it was emphasized on preparing the enamel with acid etching, since the enamel acid etching leads to a micromechanical involvement and a stronger bond with the enamel (22). A study by Peumans et al. indicated that when using Universal adhesives, the separate enamel acid etching has little effect on the bond strength. However, there are studies believing that enamel acid etching helps to increase bond strength (19, 20). Nevertheless, in our study, we etched the enamel margins separately for greater ensuring of the marginal integrity.

Moreover, a study by Marchesi et al. revealed that the dentin bonding using the Universal self-etching system is stronger over time. Although the bonding strength of the dentin appears to be initially higher in the total-etch method, but over time, it changes in favor of the self-etch approach (23). In general, some of the two-stage total-etch adhesives and single-stage adhesives are incompatible with the self-cure / dual -cure composites. This is due to the presence of hydrophilic acidic resin monomers in these adhesives (24).

In consistent with our results Oskoee and kimyai reported that low pH of 1-bottle adhesives might have contributed to high micro-leakage values (24).

In a review article by Dr Fatemeh Maleknejad et al., it was concluded that the bond strength reduction of the self-cure / dual-cure composites has an inverse relationship with the acidity level in the oxygen-inhibition layer of the adhesive system. Clinically, this means reduced polymerization and increased micro leakage (10).

The acidic monomers also react with the peroxide initiator, which produces carbon dioxide gas that generates bubbles at the interface of adhesive and composite and reduces the bonding strength.

To solve this problem, it is recommended to use an activator ingredient bottle containing a chemical curing system, benzoyl peroxide and a sulfonic acid salt (10).

The manufacturer of the Bisco-Universal Adhesives has claimed that due to the mild PH of this adhesive (PH > 3) and the presence of weak acidic monomers, this adhesive has the capability of bonding with self-cure / dual-cure composites. According to the results of this research, this claim was rejected.

Conclusion

According to the results of this study, the All Bond Universal adhesive agent used is not compatible with the Self Cure composite and can result in increased micro leakage.

References

1. Ateyah N.Z., Elhejazi A.A. Shear bond strengths and micro leakage of four types of dentin adhesive materials. J Contemp Dent Pract. 2004, 1 5; 5(1):63-73.https://doi.org/10.5005/jcdp-5-1-63

2. Hickel R., Roulet J.F., Bayne S., Heintze S.D., Mjör I.A., Peters M., Rousson V., Randall R., Schmalz G., Tyas M., Vanherle G. Recommendations for conducting controlled clinical studies of dental restorative materials. Clinical Oral Investigations. 2007, 1; 11(1):5-33. https://doi.org/10.1007/s00784-006-0095-7

3. Krämer N., Reinelt C., Richter G., Petschelt A., Frankenberger R. Nanohybrid vs. fine hybrid composite in Class II cavities: clinical results and margin analysis after four years. Dental materials. 2009, 30; 25(6):750-9. https://doi.org/10.1016/j.dental.2008.12.003

4. Shwartz RS, Summit JB, Robbins JW.,. Fundamental of operative dentistry. UK. Quintessence Co; 2006

5. Bowen R. L., Dental filling material comprising vinyl silane treated fused silica and a binder consisting of the reaction product of Bis phenol and glycidyl acrylate. 1962, 3,066,112.

6. Schroeder H. E. Oral Structural Biology. New york. Thieme; 1991

7. Buonocore M. G., A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces, J Dent Res 1955, 34: 849-853.https://doi.org/10.1177/00220345550340060801

8. USA and Canada: Ivoclar Vivadent Inc. .http://downloads.ivoclarvivadent.com/zooluwebsite/media/document/24318/Adhesive+universal. (accessed 2016)

9. Sturdevant C, Raberson T, Heyman H, Sturdevant J. The art and science of operative dentistry. 6th ed. Amsterdam. Elsevier; 2012

10. Maleknezhad F., Moosavi H., Factors contributing to the incompatibility between new adhesive systems and variouse composite composite restorations. I-dandanpezeshki. 2004; 18 (2): 15-21.

11. London, Ontario N6A 4T1Canada: 3M Canada Inc. . http://multimedia.3m.com/mws/media/754751O/scotchbond-universal-adhesive-technical-product-profile.pdf&fn=Scotchbond_uni_tpp_R2.pdf (accessed 2013)

12. Yamazaki PC, Bedran-Russo AK, Pereira PN, Swift Jr EJ. Microleakage evaluation of a new low-shrinkage composite restorative material. Operative Dentistry. 2006;31(6):670-6.https://doi.org/10.2341/05-129

13. Nemati Anaraki S, Karkehabadi H, Garchasb Zadeh NZ. Micro-leakage of three self-etch bonding agents in class 5 composite cavities. Jdm. 2016, 29(1): 39-46

14. Munoz MA, Luque I, Hass V, Reis A, Loguercio AD, Bombarda NHC. Immediate bonding properties of universal adhesives to dentine. J Dent 2013; 41(5): 404-11.https://doi.org/10.1016/j.jdent.2013.03.001

15. Van Dijken JW, Sunnegardh-Gronberg K, Sorensson E. Clinical bonding of a single-step self-etching adhesive in noncarious cervical lesions. Journal of Adhesive Dentistry. 2007; 9(4):241-9

16. Mena-Serrano A, Kose C, De Paula EA, Tay LY, Reis A, Loguercio AD, Perdigão J. A new universal simplified adhesive: 6-month clinical evaluation. Journal of Esthetic and Restorative Dentistry. 2013; 25(1):55-69. https://doi.org/10.1111/jerd.12005

17. Al-Boni R, Raja OM. Microleakage evaluation of silorane based composite versus methacrylate based composite. Journal of conservative dentistry: JCD. 2010; 13(3):15.https://doi.org/10.4103/0972-0707.71649

18. Calheiros FC, Sadek FT, Braga RR, Cardoso PE. Polymerization contraction stress of low-shrinkage composites and its correlation with microleakage in class V restorations. Journal of dentistry. 2004;32(5):407-12. https://doi.org/10.1016/j.jdent.2004.01.014

19. Hanabusa M, Mine A, Kuboki T, Momoi Y, Van Ende A, Van Meerbeek B, De Munck J. Bonding effectiveness of a new 'multi-mode'adhesive to enamel and dentine. Journal of Dentistry. 2012, 30;40(6):475-84. https://doi.org/10.1016/j.jdent.2012.02.012

20. Peumans M, De Munck J, Van Landuyt KL, Poitevin A, Lambrechts P, Van Meerbeek B. Eight-year clinical evaluation of a 2-step self-etch adhesive with and without selective enamel etching. Dental Materials. 2010, 31;26(12):1176-84.https://doi.org/10.1016/j.dental.2010.08.190

21. Motevaselian F, Yassine E, Mirzaee M, Kharazifard MJ, Heydari S, Shafiee M. In Vitro Microleakage of Class V Composite Restorations in Use of Three Adhesive Systems. Journal of Islamic Dental Association of IRAN (JIDAI). 2016;28(1):1-9.https://doi.org/10.30699/10.30699/jidai.28.1.14

22. Bahari M, Mohammadi N, Alizadeh Oskoee P, Savadi Oskoee S, Davoodi F. Effect of an extra layer of hydrophobic resin on the microleakage of Cl V composite resin restorations with a universal adhesive system. Journal of investigative and clinical dentistry. 2016;31(1):4-9.https://doi.org/10.1111/jicd.12234

23. Marchesi G, Frassetto A, Mazzoni A, Apolonio F, Diolosa M, Cadenaro M, Di Lenarda R, Pashley DH, Tay F, Breschi L. Adhesive performance of a multi-mode adhesive system: 1-year in vitro study. Journal of dentistry. 2014;42(5):603-12.https://doi.org/10.1016/j.jdent.2013.12.008

24. Kimyai S, Oskoee SS. Effect of 1-bottle light-cured adhesive acidity on microleakage of a self-cured composite. Operative dentistry. 2006;31(6):694-8. https://doi.org/10.2341/05-139