Effect of Ethanol Evaporation Time on Microleakage Using 5th-Generation Bonding Systems

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Background and objectives: Restoration microleakage is an important clinical finding, leading to secondary caries, pulp pathosis, and restoration discoloration**.** The aim of the present study was to evaluate the effect of different amounts of ethanol evaporation duration of two different 5th-generation bonding systems on the microleakage of resin composite restorations.

Materials and methods: In the present in vitro study, 60 human sound teeth were included, and class V cavity preparation was conducted on the buccal surface of each tooth. The prepared specimens were divided into six different groups (n = 10) according to the type of adhesive bond used (3M™ Adper™ Single bond, US & SoloBond™, VOCO, US) and the evaporation duration of solvent (ethanol) (none, 5 min, and 20 min). Composite restoration was conducted, and specimens underwent thermocycling. The respective teeth were rinsed in 0.5% fuchsine dye for 24h and investigated using 12x magnification of stereomicroscope. Detected microleakage was scored and analyzed using Mann-Whitney U test and Kruskal-Wallis test.

Results: There was no statistically significant difference between the groups in terms of occlusal ($p = 0.095$) and gingival ($p = 0.489$) margin median microleakage scores.

Conclusion: According to our findings, solvent evaporation had no significant effect on either occlusal or gingival microleakage severity of class V resin composite restorations with 5th-generation bonding systems.

Keywords: Class V restorations, Composite resins, Dentin-bonding agents, 5th-generation, Microleakage.

1. Introduction

Polymerization shrinkage is one of the main shortcomings of tooth-colored restorations, which leads to microleakage (1). The microleakage phenomenon has been defined as "any marginal permeability of microbial or chemical agents into tooth-restoration interface" (2). Microleakage in dental resin composite restorations is a common finding, mainly due to four-times volumetric shrinkage during composite resin polymerization (1, 2). Microleakage acts as a passage for microorganisms, fluids, ions and molecules and eventually leads to secondary caries, edge discolorations, hypersensitivity and pulpal pathosis (1).
Various methods have been used in order to minimize the risk of microleakage. However, most of them were unsuccessful. To prevent microleakage, dental bonding systems are used on the interface between preparation wall and dental restorations (3). Any bonding system is composed of two parts: a resin monomer and a solvent, which can be aqueous or non-aqueous (ethanol or acetone) (4, 5). Dental bonding should be added as a thin layer on tooth; therefore, it is diluted with solvent, another function which is to collaborate with monomers in resin structure to aid them penetrate to deeper layer of composite resins (6-8).
Despite this fact, all the solvents need to be evaporated before being cured because their presence can disrupt resin monomers polymerization (9, 10). The high density of solvent leads to low photon absorbance during light-cure, also space occupation between monomers, and eventually reduction in polymerization rate and mechanical properties of bonding systems (10-14). Thus, solvent removal is crucial for ideal bonding and dental restoration success (15, 16).
Using Prime & Bond NT bonding system, Howannaphakorn et al. did not find any significant change in microleakage rate between 0, 5, 10, and 30 minutes durations, furthermore, in all time spans (17). Since, solvent concentration has a promising role in bonding strength of different bonding systems in resin

composite restorations. The aim of the present study was to evaluate the microleakage level of different solvent evaporation durations at class V cavities restored with two 5th-generation bonding systems as an in-vitro study.

2. Materials and methods

Study protocol has been reviewed and approved by Mazandaran University of medical sciences ethical board (IR.MAZUMS.REC.1399.012). In the present in vitro study, sixty sound human mandibular premolars without any carious lesions, previous restorations, cracks, or abrasions were included. The teeth were stored in distilled water for 90 days (18). After debridement, the specimens were stored in 0.5% NaOCl solution until three days before the study, so that the probability of any infection was minimized. Class V cavity preparation was conducted on buccal surface of respective teeth (3 mm (occlusogingival height)× 4 mm (mesiodistal width) × 1.5 mm (buccolingual depth)) using a water-cooled 0.8 mm cylindrical diamond bur and a high-speed handpiece. All preparations were conducted by one dental cosmetic specialist. Both occlusal and gingival margins were in enamel. Respective bur was replaced with a newer one after seven preparations.

Etching and rinsing with water was conducted using Phosphoric acid 37.5 % (3M EPSE, St.Paul, USA) for 30 seconds (each step for 15 seconds separately). Then, the cavities were air-dried for 10 seconds. After etching, teeth were randomly assigned into six different groups (n = 10):

1) Adper™ single bond (immediately)
2) Adper™ single bonds (after 5 min solvent evaporation)
3) Adper™ single bonds (after 20 min solvent evaporation)
4) Solobond M™ (immediately)
5) Solobond M™ (after 5 min solvent evaporation)
6) Solobond M™ (after 20 min solvent evaporation)

Randomization was conducted using toss and coin method. Adper™ single bond (3M, USA) and Solobond™ (VOCO, USA) were stored in specific dishes with orange-colored leads in order to prevent curing with environment light and were stored for 20 to 50 min in room temperature.

Bonding systems were rubbed on prepared cavities per manufacturers's instructions in a double-layer for 5 seconds using mild air pressure, slightly dried for 2 secondsand light-cured for 20 seconds (19). Restoration was conducted using dental resin composite Z250 (3M, USA) with an A2 shade and with an incremental technique with two different increments, (18, 20) each one light-cured for 40 seconds. Following restoration, all teeth were immersed in distilled water for 24 hours and 37 ˚C. Thermocycling was conducted in 5-55 ˚C temperature range for 500 cycles. Specimen apices were sealed using wax and two layers of nail varnish were polished up to 1 mm around the restoration. All the specimens were immersed in 0.5% of fuchsine solution (Merck Germany) at 37 ˚C for 24 h. All specimens were immersed and rinsed with distilled water and then sectioned using a cutting machine (Nemo Co, Mashhad, Iran) into two similar halves. Die penetration was measured using stereomicroscope with a 32x magnification (Dewinter, India).

The microleakage was scored as below (21);
0 = No microleakage
1 = Penetration up to one-half of occlusal or gingival margins depth
2 = Penetration of more than one-half of occlusal or gingival margins depth
3 = Penetration to axial wall or toward pulp.

Statistical Analysis was conducted using SPSS 18.0. Concerning abnormal distribution on Kolmogorov Smirnov test, microleakage scores were reported as mean rank. Intergroup analysis was conducted using Kruskal Wallis and Mann-Whitney U test. Significance was determined as p-value < 0.05.

3. Results

Mean rank of microleakage scores both on occlusal and gingival margins were illustrated in Table 1. Our results indicated that mean rank of microleakage scores had no significant difference between groups both in occlusal ($p = 0.095$) and gingival ($p = 0.498$) margins.

Frequency of different microleakage scores were illustrated in Table 2. The highest frequency of zero score was detected in group 1 for the occlusal margin and group 5 for the gingival margin. Also, score 3 was mostly reported in group 6 for both margins. On the occlusal surface, score 1 was the highest percentage in all groups except for group 1 (score 0). While in the gingival surface, score 3 was the highest frequency in all groups except for group four (score 1). In occlusal surface, 0 and 1 microleakage score was the most abundant in group one and five respectively. While in the gingival surface, score 3 was the most frequent in all groups.

4. Discussion

In the present study, solvent evaporation was investigated in different time spans (immediately, 5, and 20 minutes), and two different bonding systems (Adper™ single bonds and SoloBond™) were investigated. Microleakage rate was investigated both in occlusal and gingival margins.

Ethanol has been used as a popular solvent in different bonding systems, this solvent has a higher vapor pressure in comparison with acetone and water, therefore, it vaporizes easier than other solvents (22). Similar to other solvents, ethanol vaporization affects bonding systems success (17).

In the present study 5th-generation bonding adhesive systems were chosen, since they are cost-effective and popular and also have better micro-shear strengths, even better than 7th-generation (23).

One of the most important requisites for an ideal dental restoration is to minimize the probability of microleakage, and

Table 1. Mean rank of microleakage scores between study groups.

Group	Mean rank	P-value
Occlusal margin		
Adper™ SB* + 0 min	50.03	0.095
Adper™ SB* + 5 min	55.25	
Adper™ SB* + 20 min	66.10	
SoloBond + 0 min	61.55	
SoloBond + 5 min	53.28	
SoloBond + 20 min	78.60	
Gingival margin		
Adper™ SB* + 0 min	57.98	0.489
Adper™ SB* + 5 min	60.98	
Adper™ SB* + 20 min	54.28	
MonSoloBond + 0 min	54.28	
MonSoloBond + 5 min	63.98	
MonSoloBond + 20 min	71.53	

Table 1. Microleakage score frequency (percentage) of each group

Margin	Score	Groups					
		1	2	3	4	5	6
Occlusal	0	9 (45%)	6 (30%)	3 (15%)	2 (10%)	1 (5%)	1 (5%)
	1	5 (25%)	8 (40%)	9 (45%)	12 (60%)	18 (90%)	9 (45%)
	2	4 (20%)	2 (10%)	3 (15%)	4 (20%)	0	2 (10%)
	3	2 (10%)	4 (20%)	5 (25%)	2 (10%)	1 (5%)	8 (40%)
Gingival	0	4 (20%)	3 (15%)	0	3 (15%)	5 (25%)	2 (10%)
	1	4 (20%)	5 (25%)	2 (10%)	9 (45%)	4 (20%)	2 (10%)
	2	1 (5%)	0	2 (10%)	2 (10%)	4 (20%)	1 (5%)
	3	11 (55%)	12 (60%)	16 (80%)	7(30%)	7 (35%)	15 (75%)
	Total	40	40	38	43	44	40

there are various methods to measure microleakage rate. Dye penetration test is one of the most valid and popular methods since it is cost-effective and easy to conduct, whereas it is less accurate and does not provide any information about bacterial penetration rate.

Yeganeh et al. in their in vitro study suggested that water storage does not change microleakage scores on class V cavities restored using Single bond systems (22). So, in the present study, Adper™ single bond was used as a model for the 5th-generation bonding system.

In the present study, microleakage rate had no significant change in different time spans for both bonding systems. Also, microleakage did not have any linear decreasing by passing time.

Howannaphakorn et al. in agreement with our finding, did not find any significant difference in microleakage rate in class V resin composite restorations using Prime & Bond NT bonding systems within 0-20 minutes evaporation durations (17).
Covering specimen with nail varnish and plastics during study process, delays their vaporization during different time spans (17). Since one of the main clinical steps to prevent further vaporization of solvents in different environments is to protect them against moisture and light, the study protocol can be a probable factor for stable vaporization of ethanol in different time spans.

5. Limitations

Our study had some limitations, first of all, the study was in vitro and certainly could not reflect real environment of oral cavity. Secondly, the role of bacterial leakage and type of teeth were not investigated in the present study, while each of them acts as a contributing factor.

6. Conclusion

According to our findings, evaporation duration of ethanol solvent did not affect microleakage rate of enamel interface with resin composite restorations, restored with 5th-generation bonding systems. Therefore, evaporation time before using 5th-generation bonding system does not affect microleakage rate.

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Authors' contribution

Ayda Sameie: Investigation, Data curation
Fathemeh Navaei: Funding acquisition
Mohadesseh Shakerian: Conceptualization, Supervision
Saman Taram: Writing – Original Draft

Conflict of Interest

None.

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References

1. Khoroushi M, Mansoori M. Marginal sealing durability of two contemporary self-etch adhesives. *ISRN Dent.* 2012;2012:204813.
2. Faria-e-silva AL, Soares PV, Baroni DB, Menezes MS, Santos-Filho PC, Soares CJ, et al. Does bonding to dentin reduce microleakage of composite restorations? *Acta Odontol Latinoam.* 2012;25:14–9.
3. Cho BH, Dickens SH, Bae JH, Chang CG, Son HH, Um CM. Effect of interfacial bond quality on the direction of polymerization shrinkage flow in resin composite restorations. *Oper Dent.* 2002;27:297–304.
4. Wang Y, Spencer P, Yao X, Brenda B. Effect of solvent content on resin hybridization in wet dentin bonding. *J Biomed Mater Res A.* 2007;82:975–83.
5. Swift EJ, Jr, Bayne SC. Shear bond strength of a new one-bottle dentin adhesive. *Am J Dent.* 1997;10:184–8.
6. Reis AF, Oliveira MT, Giannini M, De Goes MF, Rueggeberg FA. The effect of organic solvents on one-bottle adhesives' bond strength to enamel and dentin. *Oper Dent.* 2003;28:700–6.
7. Kanca J., 3rd Resin bonding to wet substrate 1. Bonding to dentin. *Quintessence Int.* 1992;23:39–41.
8. Chimeli TB, D'Alpino PH, Pereira PN, Hilgert LA, Di Hipólito V, Garcia FC. Effects of solvent evaporation on water sorption/solubility and nanoleakage of adhesive systems. *J Appl Oral Sci.* 2014;22:294–301.
9. Holmes RG, Rueggeberg FA, Callan RS, Caughman F, Chan DC, Pashley DH, et al. Effect of solvent type and content on monomer conversion of a model resin system as a thin film. *Dent Mater.* 2007;23:1506–12.
10. Dickens SH, Cho BH. Interpretation of bond failure through conversion and residual solvent measurements and Weibull analyses of flexural and microtensile bond strengths of bonding agents. *Dent Mater.* 2005;21:354–64.
11. Araújo PH, Pinto JC. Mathematical modeling of dispersion polymerizations study of the styrene polymerization in ethanol. *Braz J Chem Eng.* 2000;17:4–7.
12. Filho APN, Silva MLP, Demarquette NR. Polymer production by plasma polymerization of oxygenated organic compounds. *Polímeros: Ciência e Tecnologia.* 2002;12:280–4.
13. Venhoven BA, de Gee AJ, Davidson CL. Light initiation of dental resins: Dynamics of the polymerization. *Biomaterials.* 1996;17:2313–8.
14. Van Meerbeek B, Perdigão J, Lambrechts P, Vanherle G. The clinical performance of adhesives. *J Dent.* 1998;26:1–20.
15. Keda T, De Munck J, Shirai K, Hikita K, Inoue S, Sano H, et al. Effect of evaporation of primer components on ultimate tensile strengths of primer-adhesive mixture. *Dent Mater.* 2005;21:1051–8.
16. Torkabadi S, Nakajima M, Ikeda M, Foxton RM, Tagami J. Bonding durability of HEMA-free and HEMA-containing one-step adhesives to dentine surrounded by bonded enamel. *J Dent.* 2008;36:80–6.
17. Poptani B, Gohil KS, Ganjiwale J, Shukla M. Microtensile dentin bond strength of fifth with five seventh-generation dentin bonding agents after thermocycling: An: in vitro: study. Contemporary Clinical Dentistry. 2012 Sep 1;3(Suppl 2):S167-71..

18. Perdigão J, Swift EJ, Jr., Lopes GC. Effects of repeated use on bond strengths of one-bottle adhesives. Quintessence Int. 1999;30(12):819-23.
19. Perdigão J, Swift EJ, Jr., Lopes GC. Effects of repeated use on bond strengths of one-bottle adhesives. Quintessence Int. 1999;30(12):819
20. Owens BM, Johnson WW, Harris EF. Marginal permeability of self-etch and total-etch adhesive systems. Operative dentistry. 2006;31(1):60-7.
21. CAI, Di, et al. Review of alternative technologies for acetone-butanol-ethanol separation: Principles, state-of-the-art, and development trends. *Separation and Purification Technology*, 2022, 298: 121244.
22. Yeganeh LA, Seyed Tabaei E, Mohammadi Basir M. Bonding Durability of Four Adhesive Systems. J Dent. 2015;12(3):563-571.
23. Shafigh, E., Mahdavi, M. R., Nasiri, R. Evaluation and Comparison of Micro Shear of 5th, 7th and 8th Generation Bonding Agents in Dentin (In Vitro Study). Arch Pharma Pract 2020;11(S1):145-50

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