10.5005/jp-journals-10024-1089

ORIGINAL RESEARCH

the Journal of CONTEMPORARY DENTAL PRACTICE at www.thejcdp.com

Effect of Three Different Mouthrinses on Microleakage of Composite Resin Restorations with Two Adhesive Systems after Bleaching with 10% Carbamide Peroxide

Amir Ahmad Ajami, Mahmoud Bahari, Siavash Savadi Oskoee, Soodabeh Kimyai, Mehdi Abed Kahnamoui Sahand Rikhtegaran, Rahim Ghaffarian

ABSTRACT

Aim: The aim was to evaluate the effects of Oral-B (OB), Listerine (LN) and Rembrandt Plus (RM) mouthrinses on microleakage of composite resin restorations bonded with two adhesive systems after bleaching with 10% carbamide peroxide.

Materials and methods: A total of 60 Cl V cavities were prepared on human premolars. The occlusal and gingival margins were placed 1 mm occlusal to and apical to CEJ respectively. The teeth were randomly divided into two groups based on the adhesive system used: Excite (EX) and Clearfil SE Bond (CSE) groups. After composite resin restoration of cavities, thermocycling and bleaching with 10% carbamide peroxide for 2 hours daily for 14 days, the teeth in each adhesive group were further subdivided into three subgroups and were immersed for 12 hours in the three OB, RM and LN mouthrinses. The teeth were then placed in 2% basic fuschin for 24 hours. After dissecting the teeth, microleakage was evaluated under a stereomicroscope at 16×. Data was analyzed with multifactor ANOVA and Bonferroni test at $p < 0.05$.

Results: Microleakage with EX was significantly higher than that with CSE ($p = 0.009$). Microleakage at gingival margins was significantly higher than that at occlusal margins ($p = 0.15$). Microleakage with OB was higher than that with LN ($p = 0.02$). However, there were no significant differences in microleakage between LN and RM ($p = 1$) and between RM and OB ($p = 0.15$). In addition, with the EX adhesive system, microleakage with OB was higher than that with LN and RM ($p = 0.02$).

Conclusion: In the present study, microleakage of composite resin restorations was influenced by the type of the adhesive system, mouthrinse type and the location of the cavity margin.

Clinical significance: Use of some mouthrinses, such as OB after bleaching can increase postrestoration microleakage of resin composite restorations bonded with etch-and-rinse adhesive systems.

Keywords: Laboratory research, Adhesive system, Etch-and-rinse, Self-etch, Bleaching, Microleakage, Mouthrinse.

How to cite this article: Ajami AA, Bahari M, Oskoee SS, Kimyai S, Kahnamoui MA, Rikhtegaran S, Ghaffarian R. Effect of Three Different Mouthrinses on Microleakage of Composite Resin Restorations with Two Adhesive Systems after Bleaching with 10% Carbamide Peroxide. J Contemp Dent Pract 2012;13(1):16-22.

Source of support: This research was supported financially by the Vice Chancellor for research at Tabriz University of Medical Sciences.

Conflict of interest: There is no conflict of interest.

INTRODUCTION

Adhesive dentistry allows the use of smaller cavity preparations and preservation of tooth structure. Despite great advances in this field, there are still deficiencies in the adhesive techniques of composite resins. Probably the most important factor involved in the long-term success of composite resin restorations is microleakage, which is penetration of bacteria, liquids, molecules and ions through the tooth restoration interface. Microleakage can create clinical problems, including hypersensitivity, recurrent caries, staining of restoration margins, pulp irritation and failure of the restorative material. Therefore, prevention of microleakage is a very important consideration in the development of adhesive systems, for application in tooth restorative procedures.[1] Historically, the first adhesive systems introduced were three-step total-etch systems, which consisted of etching, priming and bonding steps, referred to as fourth generation systems. With the passage of time advances in the adhesive dentistry resulted in the development of other adhesive systems to provide higher bond strength, sealing of the tissue permeability and more importantly ease of application.[2]

At present some of the commonly used adhesive systems belong to the fifth generation, in which the primer and the adhesive have been incorporated into one bottle, but there is still need for etching. During the past decade, self-etch adhesive systems have been marketed, which are referred to as the sixth generation. These systems do not need a separate etching step, and rinsing and drying steps have been eliminated; however, a separate adhesive resin or bonding agent step is necessary.[3]

The use of bleaching agents containing peroxide to bleach vital teeth has become very popular because of long-term clinical success and high patient satisfaction since they were introduced by Haywood and Heyman.[4] Since, bleaching agents are in contact with tooth structures for a long time and there is a possibility of their inadvertent contact with dental materials, evaluation of the effect of these products on tooth structures and dental materials has attracted a lot of attention.[5-7] On the other hand, preservation of restorations in the oral cavity after bleaching procedures is a great challenge in the operative and preventive dentistry. Mechanical and chemical agents, such as toothbrushes, dental floss and mouthrinses are commonly used, especially by individuals who have previously received extensive restorative procedures.[8]

Several *in vitro* and *in vivo* studies have evaluated the therapeutic effects of mouthrinses on plaque control.[9] However, only a limited number of studies have evaluated their effect on dental materials. Recently, some clinicians have voiced concerns regarding the effect of bleaching agents on tooth-colored restorative materials.[8,10,11]

Since, bleaching agents function through the action of nascent oxygen species, they can exert effects on three-dimensional polymer network in composites and decrease polymerization degree[12] and increase microleakage.[13,14] In addition, mouthrinses, too, can induce changes in tooth structures, resulting in the same problems. For example, chlorhexidine can have an influence on the bonding procedure due to its substantivity (adsorption to tooth surfaces).[15]

Given the ever-increasing use of easy-to-use adhesive systems, application of different bleaching agents and procedures, and the use of various mouthrinses to promote oral health, the aim of the present study was to evaluate the effects of three different mouthrinses of Listerine (LN), Oral-B (OB) and Rembrandt plus (RM) on microleakage of Cl V composite resin restorations with two self-etch and etch-and-rinse adhesive systems after bleaching with 10% carbamide peroxide.

MATERIALS AND METHODS

In this *in vitro* study, 30 second human premolars extracted for orthodontic reasons were used. The teeth had mature apices and had been extracted from adolescents 1820 years of age. The teeth were free from any cracks, fractures, caries, abrasions, restorations, congenital anomalies and structural defects under visual examination and under a stereomicroscope (Nikon, SMZ 800, Tokyo, Japan). The teeth were stored in 0.5% chloramine solution until used for the purpose of the study. Before the study procedures, the teeth were cleaned of any soft tissues, debris and calculus by hand instruments and polished with a rubber cap and slurry of pumice. Class V cavities were prepared on the buccal and lingual surfaces of the teeth using an 0.8 diamond fissure bur (Diateh Dental AG, Swiss Dental Instruments, CH-9435, Heerbrugg, Switzerland) in a high-speed handpiece under air and water coolant. The cavities measured 1.5 mm in depth, 2 mm in occlusogingival dimension (1 mm coronal to CEJ and 1 mm apical to CEJ) and 3 mm mesiodistally. All the cavity margins were butt-jointed without any bevels. A new bur was used after eight preparation procedures. Then the teeth were randomly divided into two groups (n = 15) based on the adhesive system used.

In group 1, Excite adhesive resin (EX) (Ivoclar-Vivadent INC, Germany) and in group 2, Clearfil SE Bond adhesive resin (CSE) (Kurary Medical Inc, Japan) were used on cavity walls according to manufacturer's instructions. Litex 680 A light curing unit (Dentamerica, 18320 Bedford Circle, City of Industry CA 91744 USA) was used to light cure the adhesive resin according to manufacturer's instructions. The light curing probe was 8 mm in diameter and delivered a light intensity of 600 mW/cm^2 perpendicular to and barely touching the surface for 10 seconds. The light intensity of the unit was tested by a radiometer (Coltolux Light Meter, Coltene/Whaledent, Altstatten, Switzerland) before the light curing procedure. A3 shade of Filtek Z250 composite resin (3M ESPE, USA) was used to restore the cavities using the incremental technique with two 1 mm thick layers. A periodontal probe was used to check the thickness of each 1 mm layer of composite resin. Each layer was light cured for 20 seconds. Restorative procedures were carried out by one operator at a room temperature of 21ºC. After restorative procedures, all the samples were polished with diamond polishing burs (Diamant, Gmbh, DandZ, Goerzallee 307, 14167 Berlin, Germany) and polishing disks (Sof-lex™, 3M ESPE, Dental Products, St Paul, MN 55144, USA). Subsequently the specimens were incubated in distilled water at 37ºC for 24 hours. To simulate oral conditions the specimens underwent a thermocycling procedure consisting 500 cycles at 5 ± 2ºC/55 ± 2ºC with a dwell time of 30 seconds and 10 seconds for specimen transfer.

Then the teeth were dried and bleached with 10% carbamide peroxide (Pola Night, SDI Limited, Bayswater, 10Victoria 3153, Australia) for 14 days for 2 hours daily.

The teeth in each adhesive group were subdivided into three subgroups of five teeth and immersed in OB, LN and RM mouthrinses for 24 hours. Then all tooth surfaces were covered with two layers of nail varnish up to 1 mm short of the restoration margins. The apices of the teeth were sealed with utility wax. The teeth were then placed in 2% basic fuschin for 24 hours. Table 1 summarizes the composition of the materials used in the present study. After dissecting the teeth, the teeth were evaluated under a stereomicroscope (Nikon, Japan) at 16× and dye penetration at occlusal and gingival margins was classified as follows:

0: No dye penetration
I: Dye penetration up to less than half the cavity depth
II: Dye penetration more than half the cavity depth without axial wall involvement
III: Dye penetration up to the axial wall or traversing the axial wall.

DATA ANALYSIS

Data was analyzed by multifactor ANOVA. In cases in which the differences were statistically significant Bonferroni test was used for two-by-two comparisons. Statistical significance was defined at $p < 0.05$.

RESULTS

Microleakage scores are presented in Table 2. Analysis of data by multifactor ANOVA showed that the effects of adhesive system ($p = 0.009$), the type of the mouthrinse ($p = 0.024$) and the type of the margin ($p = 0.015$) on microleakage were significant. In addition, the cumulative effect of the adhesive system with the type of the mouthrinse was statistically significant ($p = 0.004$). However, the cumulative effects of the adhesive system-margin type ($p = 0.13$), mouthrinse type-margin type ($p = 0.84$) and adhesive system-margin type-mouth rinse type ($p = 0.33$) were not significant (Table 3).

Microleackage with EX was significantly higher than that with CSE ($p = 0.009$). Microleakage at gingival margins was significantly higher than that at the occlusal margins ($p = 0.015$). Two-by-two comparisons of mouthrinses with a post-hoc Bonferroni test showed significant differences in microleakage scores between LN and OB ($p = 0.02$), with no significant differences between LN and RM ($p = 1$) and between RM and OB ($p = 0.15$). Furthermore, microleakage of composite resins with the excite adhesive system subsequent to bleaching with 10% carbamide peroxide was higher after immersion in OB mouthwash compared to the other two mouthrinses under study ($p = 0.02$). However, with the CSE adhesive system

Table 2: Microleakage scores separately for each subgroup

Study groups	*Microleakage scores*			
	0	I	II	III
EX-OB-OC	0	1	6	3
EX-OB-G	0	2	2	6
EX-LN-OC	4	5	1	0
EX-LN-G	3	2	1	4
EX-RM OC	4	5	1	0
EX-RM G	2	3	1	4
CSE-OB-OC	4	4	2	0
CSE-OB-G	3	2	5	0
CSE-LN-OC	3	4	3	0
CSE-LN-G	4	3	2	1
CSE-RM OC	2	4	4	0
CSE-RM G	4	2	1	3

EX: Excite, CSE: Clearfil SE Bond, OB: Oral-B, LN: Listerine, RM: Rembrandt Plus, OC: Occlusal, G: Gingival

Table 1: The materials used in the present study

Material	*Brand*	*Composition*	*Manufacturer*
Adhesive resins	Excite	Phosphonic acid acrylate, hydroxyethyl methacrylate, Bis-GMA, dimethacrylate, highly dispersed silica, ethanol, catalysts and stabilizer	Ivoclar Vivadent, Schaan, Liechtenstein
	Clearfil SE bond	Bisphenol A diglycidyl methacrylate, 2-hydroxyethyl methacrylate, 10-methacryloyloxydecyl dihydrogen phosphate, hydrophobic aliphatic dimethacrylate, colloidal silica, dl-camphorquinone, initiators, accelerators	Kuraray Medical Inc, Okayama, Japan
Mouthrinses	Oral-B	Purified water, glycerin, polysorbote 20, flavor methyl paraben, cetylpyridinium chloride, sodium fluoride, sodium saccharin, sodium benzoate propylparaben	Oral B Laboratories, Belmont, CA, USA
	Listerine	Water, ethanol, thymol, eucalyptol, methyl salicylate, menthol, benzoic acid, poloxamer 407, caramel	Shafa Laboratories, Tehran, Iran
	Rembrandt Plus	Hydrogen peroxide solution, sodium hydroxide, saccharine, cocamidopropyl betaine glycerin,sodium citrate,PEG 40 hydrogenated castor oil	Denmat CorpSanta Maria, CA, USA
Bleaching agent	Pola night	10% carbamide peroxide, glycerine, buffered polycarboxylic acid, peppermint oil	SDI Limited, Bayswater, Victoria 3153, Australia
Composite resin	Filtek Z250	Bis-GMA, UDMA, Bis-EMA resins, zirconia/silica filler (60% by volume, particle size range of 0.01 to 3.5 μm)	3M ESPE, St Paul, MN, USA

Table 3: Tests of between-subjects effects by two-way ANOVA

Source	*Type III sum of squares*	*df*	*Mean square*	*F*	*Sig.*
Corrected model	34.367(a)	11	3.124	3.388	0.000
Intercept	208.033	1	208.033	225.578	0.000
Bonding	6.533	1	6.533	7.084	0.009
MW	7.117	2	3.558	3.858	0.024
Margin	5.633	1	5.633	6.108	0.015
Bonding* MW	10.617	2	5.308	5.756	0.004
Bonding* margin	2.133	1	2.133	2.313	0.131
MW* margin	0.317	2	0.158	0.172	0.842
Bonding* MW* margin	2.017	2	1.008	1.093	0.339
Error	99.600	108	0.922		
Total	342.000	120			
Corrected total	133.967	119			

no significant differences were observed in microleakage scores of the mouthrinses under study ($p > 0.05$) (Fig. 1).

DISCUSSION

In vitro microleakage tests provide invaluable data on the sealing ability of adhesive resins.[16] In the present study, dye penetration technique[17] was used for *in vitro* evaluation of microleakage at enamel and dentin margins with butt-jointed class V cavities. It is the most commonly used technique for microleakage evaluation.[18]

Generally, gap formation and subsequent microleakage of composite resin restorations are attributed to mechanical stresses as a result of polymerization shrinkage.[19] Factors involved in polymerization stresses are as follows in order of significance: C-factor, cavity size, the technique used to place composite resin in the cavity, the light curing technique employed, and the mechanical properties of composite resin.[20] In the present study, efforts were made to maintain all these variables in the same level for both groups. In order to keep C-factor at the same level, all the cavities were standardized with similar sizes and shapes. Furthermore, one type of composite resin and one light-curing unit were used to restore all the cavities in both groups. In addition, to simulate oral conditions, all the specimens underwent a uniform thermocycling procedure.

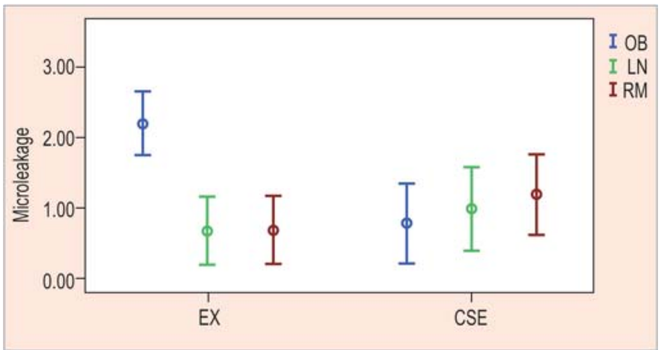

Fig. 1: Error-bar graph

The mouthrinses employed in the present study were Listerine (containing alcohol), Oral-B (alcohol-free) and Rembrandt Plus (containing H_2O_2), which represented the wide range of commercial products available on the market.

In the present study, microleakage was higher after immersion in OB compared to LN. However, unlike OB, LN contains 40% alcohol. Although alcohol-containing mouthrinses can soften Bis-GMA and UDMA-based polymers,[21] Gurgan et al[8] showed that alcohol is not the only agent to have a softening effect on composite resins. Yap et al showed that the effect of mouthrinses on composite resins and compomers depends on the material.[11] Higher microleakage values with OB might be attributed to the presence of cetylpyridinium chloride (CPC) in its chemical composition. CPC is a cationic surfactant, which can reduce surface tension of the liquid and decrease intersurface tension between a solid (gap walls here) and a liquid (basic fuchsine), resulting in an increase in wetting and penetration coefficient into the capillaries (gaps here).[22]

In the present study, etch-and-rinse (Excite) and two-step self-etch (Clearfill SE Bond) adhesive systems were used because they differ in the formation of the hybrid layer through treatment of the smear layer produced during cavity preparation.[3] The results showed that dye penetration with CSE, which contains 10-MDP (10-methacryloxydecyl dihydrogen phosphate) is less than that with etch-and-rinse systems, which is consistent with the results of previous studies.[23,24]

These findings might be attributed to differences in the chemical composition of these two adhesive systems.[25] The clinical and laboratory efficacy of adhesives containing 10-MDP has been reported by several studies.[26] It has been demonstrated that of the functional monomers used in the composition of self-etching systems, 10-MDP bonds to hydroxyapatite more easily and with a higher bond strength value.[26,27] Hayakawa et al showed that the best bond with dentin is achieved using self-etch primers containing 10-MDP,[25] which results in a minimum degree of dissolution of plaque smear and opening of dentinal tubules, reducing dentin permeability, and facilitating penetration, entanglement and polymerization of monomers with demineralized dentin.[28]

According to Buonocore, the etched enamel should be completely dry and uncontaminated, and should be penetrated by a hydrophobic resin.[29] Hadavi et al demonstrated that contact of etched enamel with primers (hydrophilic resins) might decrease the bond strength to enamel by 31 to 44%.[30] Woronko et al suggested that water-based primers, such as those used in the composition of EX should be confined to dentin.[31] However, 10-MDP contains a hydrophobic alkyl group to maintain a balance between hydrophobicity and hydrophilicity, and a double-bonded ending for effective polymerization.[26,27]

Greater microleakage with EX might be attributed to the inability of the primer to access all the demineralized areas, which results in unsupported collagen fibers and ease of gap formation; it might also be attributed to residual water molecules which prevent polymerization of the adhesive system.[32] In addition, EX contains HEMA, which results in a progressive decrease in water pressure, making it more difficult to replace the residual water molecules in the demineralized dentin. Furthermore, the hydrophobic monomer of Bis-GMA resists the diffusion into areas containing residual water molecules.[33]

Contrary to the results of the present study, the results of one study have shown less microleakage with the etch-and-rinse systems compared to self-etch systems.[34] In addition, Giachetti et al reported similar microleakage scores with the self-etch and etch-and-rinse systems at enamel and dentin margins, even after cyclic loading.[35] Several studies have shown that the efficacy of adhesive systems is more dependent on operator or application protocol rather than on the chemical composition and generation classification.[36,37] According to Giachetti et al self-etch adhesive systems are less sensitive to operator skills.[35] In addition, these systems eliminate deteriorating variables, such as over-etching, over-wetting and over-drying and are less technique-sensitive because they have eliminated the etching and rinsing steps.[38]

Another important finding of the present study was the fact that microleakage scores in both systems were higher at dentinal margins compared to enamel margins, consistent with the results of previous studies which have evaluated various adhesive systems,[39-41] although they are inconsistent with the results of some other studies.[42,43] Higher microleakage scores at dentinal margins compared to enamel margins might be attributed to differences in the chemical composition of these two margins. Although, enamel is a highly mineralized structure with more than 90% of its volume consisting of hydroxyapatite, dentin contains a large amount of water and organic content and has a wet surface, which makes bonding difficult.[44]

Various factors are involved in differences in bonding to enamel and dentin. Bonding to enamel is a relatively easy process without any special technical requirements. In contrast, bonding to dentin is somewhat challenging.[45] According to Cagidiaco et al the higher leakage observed at the cervical margin may be related to the absence of dentin tubules in the limiting 100 μm of the cervical margin and the mainly organic nature of the dentin substrate.[46] Enamel, when present at the cervical margin, is usually thin, prismless and less amendable to bonding. When polymerized, the composite resin contracts toward the superior bond at the occlusal margin and away from the weaker bond at the gingival margin.[42]

Based on the limitations of the present laboratory research, it is also recommended that microleakage evaluations be carried out with more accurate techniques with more cross-sections using electron microscopes for the evaluation of composite resin tooth structure interface in future studies. It is also important to consider the *in vitro* nature of this study and clinically, the effects of mouthrinses on restoratives may be changed by many factors in the mouth that could not be simulated in an *in vitro* study. So, it is suggested that long-term clinical studies be carried out to evaluate the effect of simultaneous use of bleaching agents and mouthrinses on microleakage of resin composite restorations bonded with different type of adhesive systems.

CONCLUSION

Based on the results of the present study, it was concluded that:

1. Microleakage scores with EX were significantly higher than those with CSE.
2. Microleakage scores at gingival margins were significantly higher than those at occlusal margins.
3. Microleakage scores with OB were higher than those with LN ($p = 0.02$); however, there were no significant differences between LN and RM and between RM and OB.
4. Microleakage scores of composite resin restorations bonded with EX adhesive system and bleached with 10% carbamide peroxide were higher after immersion in OB compared to those after immersion in LN and RM. However, with the CSE adhesive system no significant differences were observed in microleakage scores of the mouthrinses under study.

CLINICAL SIGNIFICANCE

Use of some mouthrinses, such as OB after bleaching, can increase postrestoration microleakage of resin composite restorations bonded with etch-and-rinse adhesive systems.

ACKNOWLEDGMENTS

The authors would like to thank the Vice Chancellor for research at Tabriz University of Medical Sciences for their financial support. Furthermore, the authors thank Dr M Ghojazadeh for statistical analysis of the data and Dr M Abdolrahimi, DDS, who edited the English manuscripts of this article.

REFERENCES

1. Waldman GL, Vaidyanathan TK, Vaidyanathan J. Microleakage and resin-to-dentin interface morphology of pre-etching versus self-etching adhesive systems. Open Dent J Nov 2008;28(2): 120-25.
2. Kugel G, Ferrari M. The science of bonding: From first to sixth generation. J Am Dent Assoc June 2000;131(Suppl):20S-25. Review.
3. Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. Buonocore memorial lecture. Adhesion to enamel and dentin: Current status and future challenges. Oper Dent May-June 2003;28(3):215-35.
4. Marshall K, Berry TG, Woolum J. Tooth whitening: Current status. Compend Contin Educ Dent Sep 2010;31(7): 486-92.
5. Mair L, Joiner A. The measurement of degradation and wear of three glass ionomers following peroxide bleaching. J Dent 2004;32(Suppl)1:41-45.
6. Perdigão J, Francci C, Swift EJ Jr, Ambrose WW, Lopes M. Ultra-morphological study of the interaction of dental adhesives with carbamide peroxide-bleached enamel. Am J Dent Dec 1998;11(6):291-301.
7. Schemehorn B, González-Cabezas C, Joiner A. A Sem evaluation of a 6% hydrogen peroxide tooth whitening gel on dental materials in vitro. J Dent 2004;32(Suppl)1:35-39.
8. Gurgan S, Yalcin Cakir F. The effect of three different mouthrinses on the surface hardness, gloss and colour change of bleached nano composite resins. Eur J Prosthodont Restor Dent Sep 2008;16(3):104-08.
9. Adams D, Addy M. Mouthrinses. Adv Dent Res July 1994;8(2):291-301.
10. Gürgan S, Onen A, Köprülü H. In vitro effects of alcohol-containing and alcohol-free mouthrinses on microhardness of some restorative materials. J Oral Rehabil Mar 1997;24(3): 244-46.
11. Yap AU, Tan BW, Tay LC, Chang KM, Loy TK, Mok BY. Effect of mouthrinses on microhardness and wear of composite and compomer restoratives. Oper Dent Nov-Dec 2003;28(6): 740-46.
12. Durner J, Stojanovic M, Urcan E, Spahl W, Haertel U, Hickel R, Reichl FX. Effect of hydrogen peroxide on the three-dimensional polymer network in composites. Dent Mater June 2011;27(6):573-80.
13. Yazici AR, Keleş A, Tuncer D, Başeren M. Effect of prerestorative home-bleaching on microleakage of self-etch adhesives. J Esthet Restor Dent Jun 2010;22(3):186-92.
14. Moosavi H, Ghavamnasiri M, Manari V. Effect of postoperative bleaching on marginal leakage of resin composite and resin-modified glass ionomer restorations at different delayed periods of exposure to carbamide peroxide. J Contemp Dent Pract 1 Nov, 2009;10(6):E009-16.
15. Flötra L, Gjermo P, Rölla G, Waerhaug J. Side effects of chlorhexidine mouth washes. Scand J Dent Res 1971;79(2): 119-25.
16. Korasli D, Ziraman F, Ozyurt P, Cehreli SB. Microleakage of self-etch primer/adhesives in endodontically treated teeth. J Am Dent Assoc May 2007;138(5):634-40.
17. Trowbridge HO. Model systems for determining biologic effects of microleakage. Oper Dent Autumn 1987;12(4):164-72.
18. American Dental Association Council on Dental Materials. ADA clinical protocol guidelines for dentin and enamel adhesive materials. Chicago: ADA 1993.
19. Brackett WW, Haisch LD, Pearce MG, Brackett MG. Microleakage of Class V resin composite restorations placed with self-etching adhesives. J Prosthet Dent Jan 2004;91(1): 42-45.
20. Unterbrink GL, Liebenberg WH. Flowable resin composites as filled adhesives: Literature review and clinical recommendations. Quintessence Int Apr 1999;30(4):249-57.
21. Canay S, Cehreli MC. The effect of current bleaching agents on the color of light-polymerized composites in vitro. J Prosthet Dent May 2003;89(5):474-78.
22. Atkin R, Craig VS, Wanless EJ, Biggs S. Mechanism of cationic surfactant adsorption at the solid-aqueous interface. Adv Colloid Interface Sci 30 May, 2003;103(3):219-304.
23. Haller B. Recent developments in dentin bonding. Am J Dent Feb 2000;13(1):44-50.
24. Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: A systematic review of current clinical trials. Dent Mater Sep 2005;21(9):864-81.
25. Hayakawa T, Kikutake K, Nemoto K. Influence of self-etching primer treatment on the adhesion of resin composite to polished dentin and enamel. Dent Mater Mar 1998;14(2):99-105.
26. Van Meerbeek B, Van Landuyt K, De Munck J, Hashimoto M, Peumans M, Lambrechts P, et al. Technique-sensitivity of contemporary adhesives. Dent Mater J Mar 2005;24(1):1-13.
27. Van Landuyt KL, Yoshida Y, Hirata I, Snauwaert J, De Munck J, Okazaki M, et al. Influence of the chemical structure of functional monomers on their adhesive performance. J Dent Res Aug 2008;87(8):757-61.
28. Gordan VV, Vargas MA, Cobb DS, Denehy GE. Evaluation of acidic primers in microleakage of class 5 composite resin restorations. Oper Dent Sep-Oct 1998;23(5):244-49.
29. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res Dec 1955;34(6):849-53.
30. Hadavi F, Hey JH, Ambrose ER, Louie PW, Shinkewski DJ. The effect of dentin primer on the shear bond strength between composite resin and enamel. Oper Dent Mar-Apr 1993;18(2): 61-65.
31. Woronko GA Jr, St Germain HA Jr, Meiers JC. Effect of dentin primer on the shear bond strength between composite resin and enamel. Oper Dent May-June 1996;21(3):116-21.

32. Amaral CM, Hara AT, Pimenta LA, Rodrigues AL Jr. Microleakage of hydrophilic adhesive systems in Class V composite restorations. Am J Dent Feb 2001;14(1):31-33.
33. Pashley EL, Zhang Y, Lockwood PE, Rueggeberg FA, Pashley DH. Effects of HEMA on water evaporation from water-HEMA mixtures. Dent Mater Jan 1998;14(1):6-10.
34. Pilo R, Ben-Amar A. Comparison of microleakage for three one-bottle and three multiple-step dentin bonding agents. J Prosthet Dent Aug 1999;82(2):209-13.
35. Giachetti L, Scaminaci Russo D, Bertini F, Pierleoni F, Nieri M. Effect of operator skill in relation to microleakage of total-etch and self-etch bonding systems. J Dent Apr 2007;35(4): 289-93.
36. Ernsta CP, Kötter T, Victor A, Canbek K, Brandenbusch M, Willershausen B. Marginal integrity of self and total-etching adhesives in two different application protocols. J Adhes Dent Spring 2004;6(1):25-32.
37. Miyazaki M, Onose H, Moore BK. Effect of operator variability on dentin bond strength of two-step bonding systems. Am J Dent Apr 2000;13(2):101-04.
38. Kiremitçi A, Yalçin F, Gökalp S. Bonding to enamel and dentin using self-etching adhesive systems. Quintessence Int May 2004;35(5):367-70.
39. Ben-Amar A, Pilo R, Shapinko E, Lewinstein I. A microleakage study of single-bottle adhesives applied to enamel and cementum and aged by both occlusal loading and thermocycling. Quintessence Int Mar 2005;36(3):177-82.
40. Choi KK, Condon JR, Ferracane JL. The effects of adhesive thickness on polymerization contraction stress of composite. J Dent Res Mar 2000;79(3):812-17.
41. Santini A. Microleakage of resin-based composite restorations using different solvent-based bonding agents and methods of drying acid-etched dentin. Am J Dent Aug 1999;12(4): 194-200.
42. Osorio R, Toledano M, de Leonardi G, Tay F. Microleakage and interfacial morphology of self-etching adhesives in class V resin composite restorations. J Biomed Mater Res B Appl Biomater 15 July, 2003;66(1):399-409.
43. Koliniotou-Koumpia E, Dionysopoulos P, Koumpia E. In vivo evaluation of microleakage from composites with new dentine adhesives. J Oral Rehabil Oct 2004;31(10):1014-22.
44. De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, Van Meerbeek B. A critical review of the durability of adhesion to tooth tissue: Methods and results. J Dent Res Feb 2005;84(2):118-32.
45. Arisu HD, Uçtasli MB, Eligüzeloglu E, Ozcan S, Omürlü H. The effect of occlusal loading on the microleakage of class V restorations. Oper Dent Mar-Apr 2008;33(2):135-41.
46. Cagidiaco MC, Ferrari M, Vichi A, Davidson CL. Mapping of tubule and intertubule surface areas available for bonding in class V and class II preparations. J Dent Sep 1997;25(5): 379-89.

ABOUT THE AUTHORS

Amir Ahmad Ajami

Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran

Mahmoud Bahari (Corresponding Author)

Assistant Professor, Department of Operative Dentistry, Dental and Periodontal Research Center, School of Dentistry, Tabriz University of Medical Sciences, Gholgasht Street, Zip: 5166614713, Tabriz, Iran
e-mail: bahari.dds@gmail.com

Siavash Savadi Oskoee

Associate Professor, Department of Operative Dentistry, Dental and Periodontal Research Center, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran

Soodabeh Kimyai

Associate Professor, Department of Operative Dentistry, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran

Mehdi Abed Kahnamoui

Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran

Sahand Rikhtegaran

Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran

Rahim Ghaffarian

General Dentist, Department of Operative Dentistry, School of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran