

# The Effect of Different Bonding Agent Curing Times on Microleakage of Composite Restorations in Enamel and Dentin Margins Using Two Curing Systems

M. Mirzaei<sup>1</sup>, R. Nejatbakhsh<sup>2</sup>, E. Yassini<sup>3</sup>, H. Kermanshah<sup>1</sup>, L. Ranjbar Omrani<sup>1</sup>✉

<sup>1</sup> Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Science. Tehran, Iran

<sup>2</sup> Orthodontics Postgraduate Student, School of Dentistry, Shahed University. Tehran, Iran

<sup>3</sup> Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Science. Tehran, Iran

## Abstract

**Background and Aim:** Lack of appropriate seal is one of the major problems in composite restorations. Properties of the bonding system can play a crucial role in sealing ability of these restorations. The aim of this study was to evaluate the microleakage of class V composite restorations with varying irradiation times for curing dentin bonding agents using two different curing devices.

**Materials and Methods:** In this experimental study, 60 intact extracted human molars and premolars were subjected to standard class V cavity preparations. Cavities were divided to six groups. Following etching, Excite bonding agent was applied and light cured using QTH and LED systems for 20, 30 and 40 seconds and cavities were filled with composite. The filled cavities were subjected to 3000 thermal cycles with 5-55 ° C temperatures. Teeth were immersed in 0.5% basic fuchsin dye and sectioned occlusogingivally from the restoration middle area and the microleakage was determined using stereomicroscope by a 5-scaled ranking. Data were analyzed by Mann-Whitney and Kruskal-Wallis tests with  $p < 0.05$  as the level of significance.

**Results:** No leakage was found in enamel margins. The type of light curing device did not have any significant effect on dentin margin microleakage ( $p > 0.05$ ). Furthermore, no significant differences in microleakage scores were observed in the restorations irradiated with different curing times ( $p > 0.05$ ).

**Conclusion:** QTH and LED curing units in 20, 30, and 40 s curing time did not have any significant effect on microleakage of class V composite restoration margins.

**Key Words:** Microleakage, light curing, bonding, polymerization

✉ Corresponding author:  
L. Ranjbar Omrani, Assistant Professor, Department of Operative Dentistry, School of Dentistry, Tehran University of Medical Science. Tehran, Iran  
[ladanomrani@yahoo.com](mailto:ladanomrani@yahoo.com)

Received: 26 July 2011  
Accepted: 17 July 2012

Journal of Islamic Dental Association of IRAN (JIDAI) Winter 2012 ;24, (4)

## Introduction

Superior esthetics, decreased thermal and electrical conductivity as well as the ability of bonding to tooth structure are main advantages of dental composites which have lead to their extensive use [1]. Nevertheless, stresses due to polymerization shrinkage of composites remain a problem [2]. The created stress can lead to loss of continuity in margins resulting in microleakage, especially in dentin

margins [3-4]. Microleakage cannot be diagnosed clinically but it can cause discoloration of restoration margins, destruction of marginal seal, recurrent caries, sensitivity and finally pulpal damage [5-6].

One of the factors that maintain marginal continuity is properties of adhesive layer [7]. This layer has minimal hardness in composite restorations and is considered the weakest area in the restoration.

Polymerization shrinkage can cause loss of bonding in this area [8]. It is claimed that this layer has viscoelastic strain capacity, which acts as an elastic layer and neutralizes polymerization shrinkage stress [9].

Degree of polymerization in bonding agents can influence their properties. The recommended time for curing bonding agents are 10 to 20 seconds [10]. It has been shown that improvements in mechanical properties of the bonded layer [11] can increase bond strength [12] and lead to nanoleakage reduction through increasing degree of polymerization [13-15]. On the other hand, by increasing curing time, elastic modulus and stress induced in this layer will be increased, which may cause cracks in margins of restoration either within the tooth structure or the composite thereby giving rise to loss of marginal seal and increased microleakage [16].

This study investigated the effects of different curing times of a bonding agent and increasing degree of polymerization in this layer on microleakage of composite restorations using two LED lighting and QTH devices, which are commonly used in dentistry.

### Materials and Methods

This was an *in vitro* experimental study on sixty human molar teeth without any cracks, carious lesions, or decalcification. The teeth were immediately disinfected after extraction in 0.5% chloramine T solution for one week. Then, they were stored in distilled water. The maximum storage time was three months after extraction.

Fifty-six standard class V cavities were prepared on buccal surfaces of all teeth with carbide burs. Each bur was replaced after every five cavity preparation. Cavities were prepared from mesial to distal line angles. The pulpal depth of preparation on occlusal margins were 1.25 mm. The gingival wall on the root surface had 0.75 mm pulpal depth. The axial wall followed convection of outer surface of teeth. Mesial and distal walls had a slight divergence and occlusal and gingival walls were perpendicular to the axial wall. After finishing the

preparation walls, a 0.5 mm bevel with 45° angle was prepared on the occlusal margins using a flame diamond bur. The teeth were then randomly divided to six groups. The teeth were etched for 15 sec using 35% phosphoric acid gel (Vivadent, Schaan, Liechtenstein). Then, samples were rinsed for 15 seconds and dried. A bonding agent (Excite, Vivadent, Schaan, Liechtenstein) was applied on all surfaces and, was cured in three groups using LEDemetron1 (LED, 1660 mW/cm<sup>2</sup>, Sybron Dental Specialties/Kerr, West Collins, Orange, CA, USA) device at three different exposure times of twenty, thirty and forty seconds. The other three groups were cured using Demetron Optilux 501 device (Kerr, Orange, CA, USA) at exposure times of twenty, thirty and forty seconds. In all groups, the distance between device tip and restoration was approximately zero and device tip was perpendicular to the restoration. Afterwards, the composite was inserted by layering technique in the cavity. The initial 0.5-mm-thick layer was placed on the gingival margin and axial wall to occluso-axial angle line and the subsequent layers were placed with 2 mm thickness to completely fill the cavity in each sample. Then, each layer was cured for 40 seconds. To simulate clinical conditions, the samples were incubated at 37°C for 24 hours inside a capped bottle of distilled water. After 24 hours, excess of restorative material was removed, and the surfaces polished. The samples were then subjected to 3000 thermal cycles at 5 and 55°C. After that, the end of each tooth root was sealed by wax. All tooth surfaces were completely sealed with two layers of nail polish, except for the filled parts and a 1-mm window surrounding the restored area. Then, they were maintained in an alkaline fuchsine solution (Vivadent, Schaan, Liechtenstein) for 48 hours. The samples were subsequently rinsed and mounted in transparent acrylic blocks. In the next stage, the samples were cut in the middle of the restored area on the occluso-gingival side using a diamond disc.

To investigate the influence of color penetration or microleakage, the samples were visualized under a stereomicroscope at 40x magnification and both

occlusal and gingival areas were assessed. Depth of dye penetration in the samples was numbered and determined as follows:

0. No penetration and dye leakage
1. Penetration to half or less than half of gingival or occlusal cavity depth
2. Dye penetration more than half of gingival or occlusal cavity depth
3. Dye penetration to junction of axial and gingival or occlusal without penetration into axial wall
4. Complete dye penetration and inclusion of axial wall

Mann-Whitney test was used to compare two types of systems at different times, and, Kruskal-Wallis test was used to compare the effect of time on leakage rate in each system. Significance level was considered at  $p < 0.05$ .

## Results

The incidence of severe degrees of microleakage was evident at dentin margin at twenty, thirty or forty seconds of curing for both LED and QTH devices. The frequency of severe microleakage decreased by increasing curing time and cases of no microleakage or mild microleakage increased. However, the difference was not statistically significant.

Microleakage in enamel margins were zero.

Percentage of the fourth degree of microleakage using QTH was 50% (n=5), 40% (n=4) and 30% (n=3) at curing times of 20, 30 and 40 seconds, respectively. Also, percentage of the fourth degree of microleakage using LED device was 70% (n=7), 50% (n=5), and 30% (n=3) at curing times of 20, 30 and 40 seconds, respectively. The number and percent of different degrees of microleakage are shown in Table 1 for device type and different curing times.

Comparison of percent rates of microleakage for light curing device and curing time showed that type of device had no effect on microleakage ( $p=0.79$ ). Furthermore, the effect of curing time on microleakage was not significant ( $p < 0.001$ ). In addition, the interactive effect between curing time

and the applied system on microleakage was not significant ( $p=0.88$ ).

**Table 1:** Frequency of different degrees of microleakage, mean and standard deviation in curing by different curing systems and curing times

System	Time (sec)	Indicators	Microleakage degrees				
			Zero	2	3	4	
QTH	20	number	0	3/5	0	5	5
		percent	0%	3/5	0%	50%	50%
	30	number	0	3/3	1	5	4
		percent	0%	3/3	10%	50%	40%
	40	percent	1	2/5	1	3	3
			10%	2/5	10%	30%	30%
LED	20	number	0	3/7	0	3	7
		percent	0%	3/7	0%	30%	70%
	30	percent	0	3/4	1	4	5
			0%	3/4	10%	40%	50%
	40	number	1	2/4	2	2	3
			10%	2/4	20%	20%	30%

## Discussion

There is no doubt that any method which compensates for the stresses caused by polymerization shrinkage will by some means reduce microleakage. However, to date no specific methods have been presented which can completely eliminate microleakage in dental restorations [17]. Since adhesive layer has minimum hardness in composite restorations, it is considered the weakest part in a restoration system [18]. One of the most important factors for the success of composite restorations is strong adhesion of the bonding agent to the tooth structure. Different studies have shown the relationship between degree of conversion (DC) and mechanical properties of bonding agents as bond strength [19-21]. Studies have shown that increase in polymerization rate of bonding agent reduces permeability of bonding agents in margins, nanoleakage and finally hydrolytic degradation of bond [13-15].

In this study, thermal cycles were used to get closer to clinical conditions and investigate effect of difference of coefficient thermal expansion of composite and tooth tissue on the bond. According to the results of this study, microleakage rate in

enamel margins was zero in all the groups. Considering the fact that, biological structure of the tissue as well as adhesive is effective on microleakage, it can be stated that since the main structure of enamel is composed of minerals, etching with phosphoric acid will cause suitable etching depth in enamel thereby producing a strong and good bonding through adequate penetration of the bonding material [22]. This process seems sufficient to resist against the stresses caused by polymerization shrinkage.

In contrast, dentin contains a mixture of minerals and organic materials with the main component of collagen and water, and dentin tubules filled with water. Etching with phosphoric acid, exposes collagen network in outer surfaces. Moreover, it opens dentinal tubules and increases water volume. Accordingly, sealing in dentin is very complex and histological findings have shown higher microleakage rate in dentin margins compared to enamel margins in composite cavities [23].

The results showed that the type of curing device had no effect on microleakage of restorations and that microleakage severity decreased by increasing exposure time. Nonetheless, this decrease was not statistically significant.

According to the results of this study and previous studies on adhesive resins, it seems that increased rate of polymerization is effective in reducing leakage in dentin margin. In fact, by increasing curing time, the changes in elastic and mechanical properties of bonded layers cannot increase microleakage, and the cohesive strength of adhesive layer is more than shrinkage stress induced in composite resins. In addition, it can resist the difference of coefficient of thermal expansion.

### Conclusion

The results of this study showed that increasing exposure time of bonding agent to 40 sec not only did not increase microleakage between composite and teeth restoration, but also reduced microleakage severity in dentin margin to some degrees. The kind of light curing device had no evident effect in this regard.

### References

- 1- Hickel R, Dasch W, Janda R. New direct restorative materials. *Int Dent J.* 1998 Feb; 48(15): 3-16.
- 2- Yap AUJ, Wang HB, Siow KS, Gan LM. Polymerization shrinkage of visible - cured composites. *Oper Dent Mater.* 2000 Mar-Apr 25(2):98-103.
- 3- Peutzfeldt A, Asmussen E. Determinants of in vitro gap formation of resin composites. *J Dent.* 2004 Feb; 32(2):109-15.
- 4- Braga RR, Ferracane JL. Alternatives in polymerization contraction stress management. *Crit Rev Oral Biol Med.* 2004 Jun; 15(3):176-84.
- 5- Sturdevant C, Roberson T, Heymann H, Sturdevant J. *The art and science of operative dentistry.* 4th ed. St. Louis: The CV Mosby Co; 2002, Chap4:133-234.
- 6- Santos A, Lisso M, Aguiar F, Franca F, Lovadino J. Effect of stepped exposure on quantitative in vitro marginal microleakage. *J Esthet Restor Dent.* 2005; 17(4):236-242.
- 7- Zheng L, Pereira PNR, Nakajima M, Sano H, Tagami J. Relationship between adhesive thickness and microtensile bond strength. *Oper Dent.* 2001 Jan-Feb; 26(1):97-104.
- 8- Lin C, Douglas WH. Failure mechanisms at the human dentin-resin interface: A fracture mechanics approach. *J Biomech.* 1994 Aug; 27(8): 1037-47.
- 9- Feilzer AJ, Dooren EH, DeGee AJ, Davidson CL. Influence of light intensity on polymerization shrinkage and integrity of restoration-cavity interface. *Eur J Oral Sci.* 1995 Aug; 103(8):322-6.
- 10- Labella R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerisation shrinkage and elasticity of flowable composites and filled adhesives. *Dent Mater.* 1999 Mar; 15(2):128-137.
- 11- Dickens SH, Cho BH. Interpretation of bond failure through conversion and residual solvent measurements and Weibull analysis of flexural and microtensile bond strengths of bonding agents. *Dent Mater.* 2005 Apr; 21(4):354-364.

- 12- Kermanshah H, Yassini E, Kharazi-fard M, Bitaraf T. [Effect of curing time and application of one bottle bonding on shear bond strength of composite to dentin]. *J Islamic Dent Ass.* 2010 winter; 21(4):250-56. (Persian)
- 13- Cadenaro M, Antonioli F, Sauro S, Tay FR, Di Lenarda R, Prati C, Biasotto M, Contardo L, Breschi L. Degree of conversion and permeability of dental adhesives. *Eur J Oral Sci.* 2005 Dec; 113(6):525-530.
- 14- Navarra CO, Cadenaro M, Armstrong SR, Jessop J, Antonioli F, Sergio V, Di Lenarda R & Breschi L Degree of conversion of filtek silorane adhesive system and clearfil SE bond within the hybrid and adhesive layer: An in situ raman analysis. *Dent Mater.* 2009 Sep; 25(9):1178-1185.
- 15- Navarra CO, Cadenaro M, Codan B, Mazzoni A, Sergio V, De Stefano Dorigo E & Breschi L. Degree of conversion and interfacial nanoleakage expression of three onestepself-etch adhesives. *European J of Oral Sci.* 2009Aug; 117(4):463-469.
- 16- Unterbrink GL, Leibenberg WH. Flowable resin composites as filled adhesives: Literature review and clinical recommendations. *Quintessence Int.* 1999 Apr;30(4):249-57.
- 17- Garcia AD, Lozano MAM, Vila JC, Escribano AB, Glave PF. Composite resins. A review of the materials and clinical indications. *Med Oral Pathol Oral Cir Bucal.* 2006 Mar; 11(2):215-220.
- 18- B. Van Meerbeek, G. Willems, JP. Celis, JR. Roos, M. Braem, P. Lambrechts and G. Vanherle, Assessment by nano-indentation of the hardness and elasticity of the resin-dentin bonding area, *J Dent Res.* 1993 Oct 72(10):1434-1442.
- 19- Kim JS, Kim MS, Lee IB, Son HH, UmCM, Kim CK & Kim OY Adhesive layer properties as a determinant of dentin bond strength Bae JH, Cho BH. *J Biomed Mater Res. Part B: App Biom.* 2005 Aug 74(2):822-828.
- 20- 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 Apr; 21(4):354-364.
- 21- Kanehira M, Finger WJ, Hoffmann M, Endo T & Komatsu M. Relationship between degree of polymerization and enamel bonding strength with self-etching adhesives. *J Adhesive Dent.* 2006 Aug; 8(4):211-216.
- 22- Coelho S, Santos GC. Effect of light curing method on volumetric polymerization shrinkage of resin composites. *Oper Dent.* 2004 Mar-Apr; 29(2):157-161.
- 23- Faria e Silva AL, Lima AF, Moraes RR, Piva E, Martins LR. Degrees of Conversion of etch and rinse and self etch Adhesives Light-cured using QTH or LED. *Oper Dent.* 2010 Nov-Dec; 35(6):649-654.