

Evaluation of Effect of Adding Silica Fillers to Adhesive on Microleakage of Composite Restorations in Different Times

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Abstract

Background and Aim: Dental adhesives are widely used in modern dentistry to provide retention of composite resin restoration and to reduce associated marginal microleakage. We aimed to evaluate the effect of adding silica fillers to adhesive on microleakage of composite restorations in different times.

Materials and Methods: Forty-eight premolars were collected in 0.5% chloramine T solution. The teeth were divided into two groups. CLV cavities were prepared. In the first group, SE bond and in the second group, experimental unfilled SE bond were applied. In subgroups 1 of both groups, the teeth were incubated for 3 months then evaluated. In subgroups 2 of both groups, evaluation was performed after 24 hours. Cavities were filled with Z250 composite resin. Before incubation, samples were thermocycled at 5 to 55° C in 1000 cycles, then immersed in silver nitrate solution and afterwards developer solution for microleakage evaluation. They were then mounted, sectioned and observed under stereomicroscope and scanning electron microscope for scoring. The data were analyzed with Kruskal-Wallis and Mann-Whitney tests.

Results: There was significant difference in microleakage between groups in different times. There was no significant difference between occlusal microleakage regardless of time ($p < 0.001$). The difference between cervical microleakage of two adhesive types was not significant ($p = 0.533$). There was significant difference between 24 hours and 3 months storage ($p < 0.001$). No significant difference was detected between filled and unfilled adhesives regardless of time ($p < 0.001$).

Conclusion: Although there was no significant difference between the two adhesives, unfilled adhesives performed slightly better than filled adhesives.

Key Words: Microleakage, Filled adhesive, Composite filling

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Introduction

The increasing trend towards esthetic tooth-colored restorations and replacing previous amalgam restorations with them has led to various investigations [1]. An ideal restoration provides a thorough and permanent seal in tooth-restoration interface. Inadequate bonding causes microbial leakage allowing bacteria, fluids, ions

and molecules to penetrate through tooth-restoration interface—a process called microleakage. This can lead to marginal discoloration, secondary caries and even pulpal irritation [2, 3]. Gap formation may be due to polymerization shrinkage of composite or uneven elastic modulus of the tooth in comparison with that of composite [4]. After application of acid etching

by Bonnocore in 1955 a significant reduction of microleakage was seen in enamel margin of restorations [5]. A complete resin penetration to the depth of the demineralized area is necessary to have maximal bond strength and to prevent microleakage and secondary caries [6]. Nowadays, it is declared in the literature that filler containing adhesives can act as a decompression agent to compensate stresses due to polymerization shrinkage [7,8]. Current bonding systems usually show high bond strengths after 24 hours of immersion under water. On the other hand, various laboratory studies concerning bond durability after several months showed that a decrease in bond strength is observed [9-11]. Acid etching removes 10 microns from the surface of enamel leaving a porous layer as deep as 5-50 microns. Then, resins of low viscosity wet enamel surface through the capillary property. [12] Copolymerization of carbon-carbon diploid bonds between adhesive and the matrix phase of composite produces a strong chemo-mechanical bond that usually provides a shear bond strength of 20 mega-pascals [13]. Dentin has a heterogeneous, moist and dynamic structure with a high organic content, odontoblastic processes and intratubular fluid [14]. For the majority of adhesive systems, dentin adhesion is achieved through formation of hybrid layer which was described first by Nakabayashi [15]. Hybrid layer is formed following primary demineralization of dentin surface and exposure of a network of collagen fibers which are penetrated by low-viscosity monomers [16]. Although some degrees of microleakage is present in most of the dental materials, minimal microleakage events are well tolerated by pulp and their irritation is dominated by the pulpal blood flow [17,18]. Enamel margin usually provide durable bonds and possess less microleakage in comparison with dentin walls. [19,20]. Clinically, margins located below the cemento-enamel junction (CEJ) are more problematic in terms of moisture control, and dentin bonding, because the dentin has a non-homogenous structure and in addition hydroxy-

apatite content, collagen, smear layer, dentinal tubules, and dentinal fluid must be taken into consideration when dentin bonding is contemplated [2]. Filler incorporation causes improvement of mechanical properties including increase in strength and hardness, decrease of dimensional changes and prevention of crack propagation. [21,22]. Nowadays, some articles state that filler containing adhesives act as an elastic shock-absorbing layer and compensate stresses of polymerization [7,8].

Although numerous comparisons have been carried out concerning bond strength of commercial adhesives with and without filler incorporation, it is still unclear whether filler incorporation can increase bond strength and decrease microleakage due to the diversity in composition and matrix formulation of fillers and adhesives.

The objective of this study was to evaluate the influence of filler particles incorporation in adhesive composition on microleakage of composite restorations.

Materials and Methods

A total of 48 premolars were stored in 0.5% chloramine T solution. Class V cavities were prepared. Primer (Kurrury, Japan) was applied on each cavity for 20 seconds. Then bonding agent was applied on primed cavities and cured for 10 seconds. Samples were categorized into two groups of 24. Samples in group 1 were restored by filler containing SE Bond and those in group 2 were filled using a trial adhesive (manufactured exclusively for this research by Kurrury Co., Japan) Teeth in both groups were divided into the following subgroups following composite restoration and application of 1000 thermal cycles between 5-55 degrees centigrade. The samples in first subgroup of each group were incubated at 37 degrees centigrade for three months, but those in the second subgroup were evaluated after 24 hours. Two layers of nail varnish was applied to all tooth surfaces except for a 1-mm distance around the each cavity. The apices were sealed by sticky wax. Teeth were

stored in silver nitrate solution for 24 hours and radiographic developing solution for 8 hours under fluorescent light. All samples were then mounted, sectioned and visualized under a stereomicroscope (Nikon Inc., Garden City, NY, USA) under 32x magnification and a scanning electron microscope (SEM). Data were analyzed by Kruskal-Wallis and Mann-Whitney statistical tests. Microleakage was scored as follows [30]:

In occlusal margin:

Score 0: no microleakage

Score 1: dye penetration up to ½ of enamel thickness

Score 2: dye penetration up to whole enamel thickness passing through DEJ

Score 3: dye penetration up to the depth of the cavity

Score 4: dye penetration beyond the cavity towards pulp

In cervical margin:

Score 0: no leakage

Score 1: dye penetration up to 1/3 of dentin thickness

Score 2: dye penetration up to 2/3 of cavity dentin thickness

Score 3: dye penetration up to the depth of the cavity

Score 4: dye penetration beyond the cavity towards pulp

Results

Frequency distribution of microleakage score in cervical and occlusal margins in adhesives with and without filler are illustrated in 24h and 3 months in tables 1 and 2. Kruskal-Wallis statistical test indicated a significant difference between the groups. Mann-Whitney test showed that there was no statistically significant difference between the frequency of microleakage in cervical and occlusal margins in the two types of adhesives regardless of time. (p=0.533) Mann-Whitney test also showed that there was a significant difference in frequency of microleakage in cervical and occlusal areas between 24h and 3 months regardless of filler incorporation.

Table 1: frequency distribution of cervical microleakage scores in adhesives with and without filler in 24 hours and 3 months

Filler		time			total
		immediately	3 months		
Filler containing	Cervical microleakage	0	2	1	3
		1	3	0	3
		2	4	3	7
		3	3	2	5
		4	0	6	6
	sum		12	12	24
Non-filler containing	Cervical microleakage	0	8	0	8
		1	1	1	2
		2	1	2	3
		3	2	2	4
		4	0	7	7
	sum		12	12	24

Table 2: frequency distribution of occlusal microleakage scores in adhesives with and without filler in 24 hours and 3 months

Filler		time			total
		immediately	3 months		
Filler containing	Occlusal microleakage	0	2	8	10
		1	3	2	5
		2	3	1	4
		3	4	0	4
		4	0	1	1
	sum		12	12	24
Non-filler containing	Occlusal microleakage	0	3	6	9
		1	1	6	7
		2	6	0	6
		3	2	0	2
		4	0	0	0
	sum		12	12	24

(p<0.001) It was also indicated that the difference between microleakage score frequency in cervical margin between 24 hours and 3 months was statistically significant in the filler containing adhesive group.(p=0.012) Such difference was also considered significant in occlusal margins. (p=0.024)

Within non-filler containing adhesive group, the difference between frequency of microleakage scores was significant in the two intervals of 24 hours and 3 months in both cervical ($p < 0.001$) and occlusal ($p = 0.014$) margins.

Discussion

Numerous authors have considered leakage in combination with bond strength studies an appropriate means for determination of clinical acceptability of adhesive systems [23]. This study indicated that microleakage occurred more in cervical than in occlusal margins. This was in accordance with other authors who investigated different composite resins and bonding agents in class I and class II restorations [24-27]. The difference in occlusal and cervical microleakage is attributable to the structural differences of enamel and dentin.

SE Bond contains 10% micro-sized silanated colloidal silica particles. The results of the current study showed no significant difference between commercial and experimental SE Bond systems. Cardoso et al failed to indicate any significant difference between commercial and experimental prime & bond NT [28]. Nunes and coworkers reported that there was no significant difference in micro-tensile strength of NT with and without fillers [21]. They found a significant difference in micro-tensile strength between SingleBond and experimental SingleB and described that the difference was related to the size of filler so that nanofillers pass through collagen fibrils in NT but this does not occur in experimental SingleB because their 0.6-micrometer size does not allow penetration into the 20-nanometer interfibrillar space [23]. Tay et al found that nanofillers are accumulated at the tubules orifices but could not be found through interfibrillar hybrid layer [29]. SEM evaluation in this study showed that nonfiller adhesives slightly outperformed filler-containing counterparts because the length of resin tags were two times that of filled adhesives. Resin tags are more irregular in the filled adhesive because of

accumulation of filler particles within interfibrillar spaces. (Fig.1)

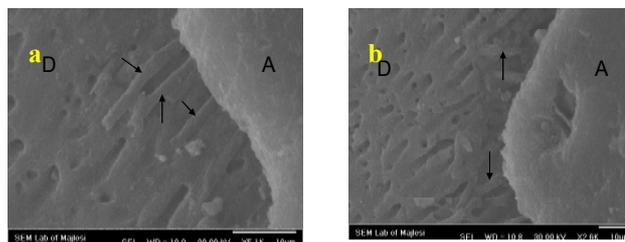


Figure 1: Scanning electron micrograph of filled and unfilled SE Bond. a) low-magnification representation of bonding area in unfilled adhesive {(D) dentin, (A) adhesive} Arrows indicate resin tags. b) the same magnification representing bonding area in filled adhesive

In composition of a monomer that contains hydrophilic and hydrophobic monomers, there is a possibility for separation of hydrophilic monomers. Along with this process some monomers produce inactive rings inside hydrophobic monomers which are called micelles. Water is entrapped within micelles via hydrogen bonds. These areas are highly permeable in a polymerized adhesive. Silver ion is 2.5 Å in diameter but a water molecule is reported to be 3.0 Å in diameter. According to the potential spaces present in the adhesive (12-88 nm), water and indicator should easily penetrate into adhesive layer. These spaces provide channels for water absorption into adhesives and fluoride ion release. Therefore microleakage was present contrary to the presence of bonding and hybrid layer [30].

Conclusion

It was indicated that filled and experimental adhesives failed to prevent microleakage regardless of filler incorporation. The unfilled adhesive showed less microleakage than the filled counterpart did but the difference was not statistically significant. An increase in microleakage was observed following 3 months in both filled and unfilled groups.

References

- 1-Ateyah NZ, Elhejazi AA. Shear bond strength and microleakage of four types of dentin adhesive materials. *J Contemp Dent Pract.* 2004 Feb 15;5(1):63-73.
- 2-Stockton LW, Tsang ST. Microleakage of class II posterior composite restoration with gingival margins entirely within dentin. *J Can Dent Assoc.* 2007 Apr;73(3):255.
- 3-Sadek FT, Moura SK, Ballester RY, Muench A, Cardoso PE. The effect of long-term storage on the microleakage on composite resin restoration – qualitative and quantitative evaluation. *Pesqui Odontol Bras.* 2003 Jul-Sep;17(3):261-6.
- 4-Barkmeier WW, Cooley RL. Laboratory evaluation of adhesive systems. *Oper Dent.* 1992; Suppl 5:50-61. Review.
- 5-Borges MA, Matos IC. Influence of two self-etching primer systems on enamel adhesion. *Braz Dent J.* 2007 Feb;18(2):113-8.
- 6-Ben – Amar A, Shapinko E. A microleakage study of single-bottle adhesives applied to enamel and cementum and aged by both occlusal loading and thermocycling. *Quintessence Int.* 2005 Mar;36(3):177-82.
- 7-Harada ST, Pazinato FB, Wang L, Atta MT. Effect of number coats of simplified adhesive systems on microleakage of dentin-bordered composite restorative. *J Contemp Dent Pract.* 2006 Nov 1;7(5):34-41.
- 8-Pongprueksa P, Kuphasuk W, Senawongse P. Effect of elastic cavity wall and occlusal loading on microleakage and dentin bond strength. *Oper Dent.* 2007 Sep-Oct;32(5):466-75.
- 9-Carrilho MR, Carvalho RM, Tay FR, Pashley DH. Effect of storage media on mechanical properties of adhesive systems. *Am J Dent.* 2004 Apr;17(2):104-8.
- 10-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 result. *J Dent Res.* 2005 Feb;84(2):118-32.
- 11-Armstrong SR, Keller JC, Boyer DB. The influence of water storage and C-factor on the dentin-resin composite microtensile bond strength and debond pathway utilizing a filled and unfilled adhesive resin. *Dent Mater.* 2001 May;17(3):268-76.
- 12-Silverston LM, Saxton CA, Dogon IL, Fejerskov O. Variation in pattern of etching of human dental enamel examined by scanning electron microscopy. *Caries Res.* 1975;9(5):373-87.
- 13-Eick JD, Robinson SJ, Chappell RP, Cobb CM, Spencer P. The dentinal surface: Its influence on dentinal adhesion. part III. *Quintessence Int.* 1993 Aug; 24(8):571-82.
- 14-Frankenberger R, Krämer N, Oberschachtsiek H, Petschelt A. Dentin bond strength and marginal adaptation after NaOCl pre-treatment. *Oper Dent.* 2000 Jan-Feb;25(1):40-5.
- 15-Torres CR, de Araújo MA, Torres AC. Effects of dentin collagen removal on microleakage of bonded restorations. *J Adhes Dent.* 2004 Spring;6(1):33-42.
- 16-Maior JR, Da Figueira MA, Netto AB, de Souza FB, da Silva CH, Tredwin CJ. The importance of dentin collagen fibrils on the marginal sealing of adhesive restorations. *Oper Dent.* 2007 May-Jun;32(3):261-5.
- 17-Idriss S, Abduljabbar T, Habib C, Omar R. Factors associated with microleakage in class II resin composite restorations. *Oper Dent.* 2007 Jan-Feb;32(1):60-6.
- 18-Alani AH, Toh GC. Detection of microleakage around dental restoration: review. *Oper Dent.* 1997 Jul-Aug;22(4):173-85.
- 19-Hilton TJ, Schwartz RS, Ferracane JL. Microleakage of four class II resin composite restoration insertion techniques at intraoral temperature. *Quintessence Int.* 1997 Feb;28(2):135-44.
- 20-Labela R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. *Dent Mater.* 1999 Mar;15(2):128-37.
- 21-Nunes MF, Swift EJ, Perdigão J. Effect of adhesive composition on microtensile bond

- strength to human dentin. *Am J Dent.* 2001 Dec;14(6):340-3.
- 22-Montes MA, de Goes MF, da Cunha MR, Soares AB. A morphological and tensile bond strength evaluation of unfilled adhesive with low viscosity composites and a filled adhesive in one and two coats. *J Dent.* 2001 Aug;29(6):435-41.
- 23-Arisu HD, Uçtasli MB, Eligüzeloglu E, Ozcan S, Omürlü H. The effect of occlusal loading on the microleakage of class V restorations. *Oper Dent.* 2008 Mar-Apr;33(2):135-41.
- 24-Delme KI, Deman PJ, De Moor RJ. Microleakage of class V resin composite restorations after conventional and Er:YAG laser preparation. *Journal of oral rehabilitation J Oral Rehabil.* 2005 Sep;32(9):676-85.
- 25-Guix P, Picornell A, Parera M, Galmes A, Obrador A, Ramon MM, Castro JA. Distribution of HFE C282Y and H63D mutations in the Balearic Islands (NE Spain). *Clin Genet.* 2002 Jan; 61(1):43-8.
- 26-Chimello DT, Chinelatti MA, Ramos RP, Palma Dibb RG. In vitro evaluation of microleakage of a flowable composite in Class V restorations. *Braz Dent J.* 2002;13(3):184-7.
- 27-Opdam NJ, Roeters JJ, Burgersdijk RC. Microleakage of Class II box-type composite restorations. *Am J Dent.* 1998 Aug;11(4):160-4.
- 28-Cardoso PE, Placido E, Francci CE, Perdigão J. Microleakage of Class V resin-based composite restorations using five simplified adhesive systems. *Am J Dent.* 1999 Dec;12(6):291-4.
- 29-Tay FR, King NM, Chan KM, Pashley DH. How can nanoleakage occur in self-etching adhesive systems that demineralize and infiltrate simultaneously? *J Adhes Dent.* 2002 Winter;4(4):255-69.
- 30-Erdilek D, Dorter C, Koray F. Effect of thermo-mechanical load cycling on microleakage in CIII ormocer restorations. *Eur J Dent.* 2009 Jul;3(3):200-5.