Original Article

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 pro vide 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 steriomicroscope 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 be tween 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] Co-polymerization 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-viscsity 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 cementoenamel junction (CEJ) are more problematic in terms of moisture control, and dentin bonding, because the dentin has a non-homogenous structure and in addition hydroxyapatite 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 (Kurrary, 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 Kurrary 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. ($p<0.001$) 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. ($p=0.024$)

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

Filler			**time**		
			immediately	**3 months**	**total**
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**		
			immediately	**3 months**	**total**
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
		sum	12	12	24

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 intefibrillar 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)

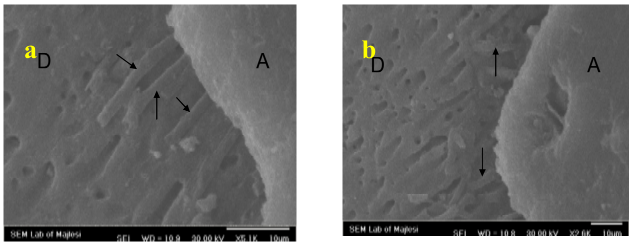

Figure 1: Scanning electron micrograph of filled and unfilled SE Bond. a) low-magnification representation of bonding area in unfilled adhesive {(D) dentin, (A) adhesive} Arrows indicate resin tags. b) the same magnification representing bonding area in filled adhesive

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 Δ in diameter but a water molecule is reported to be 3.0 Δ 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.

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