Effect of Elapsed Time Following Bleaching on Microleakage of Resin Composite Restorations

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Abstract

The elapsed time prior to the placement of bonded restoration possibly affects the bond integrity of resin composite to bleached tooth. The purpose of this study was to evaluate the effect of elapsed time after tooth bleaching on microleakage of resin composite restorations with different adhesive systems. Seventy-two extracted sound human premolars were randomly divided into 6 groups of 12 teeth each. Group I was a control group without tooth bleaching. Group II to VI were bleached with 10% carbamide peroxide using custom bleaching trays for 14 days. Group II-VI represented immediate, 1, 7, 14, and 28 days time interval between bleaching process and bonding procedure, respectively. After the elapsed time of each group, class V cavities (3x4x1.5 mm) were prepared on both buccal and lingual aspects of each tooth. An occlusal margin of the prepared cavities was placed on enamel and a cervical margin was located on root surface. All teeth of each group were treated with either an etch-and-rinse adhesive (Single Bond 2; SB) or a self-etching primer adhesive (Clearfil SE Bond X; SE), and were subsequently bulk-filled with resin composite followed by light-cured for 40 sec. Restored teeth were polished and soaked in 2% methylene blue for 2 hours. The specimens were longitudinally cut through the restored cavities with a slow-speed diamond saw obtaining three slabs for each cavity. The median scores of dye penetration were analyzed using Kruskal-Wallis test. There was no statistically significant difference in microleakage among the elapsed time after tooth bleaching ($p>0.05$) regardless of adhesive systems used, although, group II and III showed higher dye penetration score compared to other groups. At cervical wall, SB performed significantly higher microleakage than SE (Mann-Whitney U tests $p<0.05$).

Keywords: elapsed time, bleaching, microleakage, resin composite

Introduction

Vital tooth bleaching is a conservative treatment of surface and intrinsic staining of teeth (Matis, et al., 1998). In particular, home bleaching which employed carbamide peroxide, introduced in 1989 by Haywood and Heymann, has been described as a safe alternative for vital discolored tooth (Haywood & Heymann, 1989). Recently, a study has reported that tooth bleaching is comparatively safe in terms of potential risk for alteration of dental hard tissue (Dadoun & Bartlett, 2003). Only slight surface modification of teeth treated with carbamide peroxide was observed (Bitter, 1992; McGuckin, et al., 1992; Shannon, et al., 1993). However, several studies have demonstrated that no change in hardness occurs on the surface of enamel after carbamide peroxide treatment (Mc Cracken & Haywood, 1996; Murchison, et al., 1992; Nathoo, et al., 1994; Shannon, et al., 1993).

Regarding the bond strength of resin composite restoration after bleaching procedures, the immediate bond strength of adhesive systems to bleached enamel can be affected by the bleaching solution. Previous studies have shown reductions in the immediate tensile and shear bond strength of resin composite to bleached teeth (Titley, et al., 1992; Titley, et al., 1993; Titley, et al., 1988; Torneck, et al., 1990; van der Vyver, et al., 1997). However, the bond strength returns to pretreatment levels after 2 weeks (Cullen, et al., 1993; Sung, et al., 1999). Although there are not clear explanations as to their occurrence, some studies suggested the interference of residual oxygen in the resin-bonding restorative procedure that follows the bleaching process (Titley, et al., 1992; Titley, et al., 1993; Titley, et al., 1988; Torneck, et al., 1990; van der Vyver, et al., 1997).

The marginal seal of restoration could also be affected by the bleaching reactions (Barkhordar, et al., 1997; Shinohara, et al., 2001). The increase in the microleakage of oral fluids and bacteria between the restorative/tooth interfaces may contribute to the failure of the restoration. In order to avoid these undesirable effects, elapsed time has been advocated between bleaching and restorative procedures (Haywood, 1992). It is hypothesized that this elapsed time could be an important factor in obtaining a satisfactory sealing after bleaching, probably eliminating traces of bleaching reactions.

Over the past decade, many of adhesive systems were developed. Currently, two-step etch-and-rinse and two-step self-etch adhesive systems are widely used as bonding agents for resin composite restorations. Two-step etch-and-rinse adhesive system includes application of the etching agent and application of the primer combined with the bonding agent. A number of studies reported effective bonding efficacy of this two-step etch-and-rinse adhesives (Frankenberger & Tay, 2005; Peumans, et al., 2005). Self-etch adhesive system includes the non-rinsing acidic monomer, which can etch and prime the tooth surface simultaneously. Elimination of the rinsing step and partial removal of the smear layer and smear plugs with these adhesives leads to less technique-sensitive and time-consuming procedures. The bonding quality of these self-etch adhesives is still controversial. Some studies reported a lower bonding effectiveness with these systems compared to etch-and-rinse adhesives (de Munck, et al., 2005; van Landuyt, et al., 2006), while others found a similar bonding effectiveness (Lopes, et al., 2004; Wang, et al., 2004). Ermis, et al. (2009) recently demonstrated that both of the adhesive systems had similar clinical performance in two-year clinical trial. The data regarding to the effect of tooth bleaching to these two different adhesive systems is limited.

The purpose of this study was to evaluate the effect of elapsed time after tooth bleaching on microleakage of resin composite restorations with two different adhesive systems.

Materials and Methods

Specimen preparation

Seventy-two sound human premolars, extracted for orthodontic reasons, were collected in 1% thymol solution. This research was approved by the ethical committee on human rights related to research involving human subjects, Naresuan University. The teeth were cleaned and then randomly divided into 6 groups of 12 teeth each according to the time interval between bleaching and bonding procedures. The materials used in this study are shown in Table 1.

Table 1 Lists of Dental Materials used

Material	Manufacturer	Batch number	Composition
Opalescence	Ultradent Products, UT, USA	B2K9Z	10% carbamide peroxide, carbopol, glycerin
Z 250 (shade A3)	3M ESPE, MN, USA	7HY	Zirconia/silica filler, resin mixture of Bis-GMA, UDMA, Bis-EMA
Single Bond 2	3M ESPE, MN, USA	Etchant: 7LG Bond: 7JW	35% phosphoric acid HEMA, Bis-GMA, dimethacrylates, methacrylates pendant polyalkenoic acid copolymer, photoinitiator, ethanol, water
Bonding procedure:	a (15s), b, c, d, e, f (10s)		
Clearfil SE Bond X	Kuraray Medical, Tokyo, Japan	Primer: 00715A Bond: 01024A	MDP, HEMA, water, hydrophilic dimethacrylates, photoinitiator, accelerator MDP, HEMA, Bis-GMA, hydrophobic dimethacrylates, microfiller, photoinitiator, accelerator
Bonding procedure:	g (20s) , h, d, e, f (10s)		

HEMA: 2-hydroxyethyl methacrylate
Bis-GMA: bisphenol A diglycidyl ether dimethacrylate
MDP: 10-methacryloyloxydecyl dihydrogen phosphate
TEGDMA: triethylene glycol dimethacrylate
UDMA: urethane dimethacrylate
Bis-EMA: bisphenol A polyethylene glycol diether dimethacrylate
Procedure step: (a) acid-etch; (b) rinse with water; (c) blot dry; (d) apply adhesive; (e) gently air blow; (f) light-cure; (g) active priming; (h) gently air dry

Group I was performed as a control group without tooth bleaching. The teeth in group II to VI were bleached with 10% carbamide peroxide (Opalescence, Ultradent Products, Inc., Salt Lake City, UT, USA) using custom bleaching trays (one application per day) at 8 hours daily for 14 consecutive days. During the bleaching period and the remaining hours after bleaching in the day, specimens were stored under 100% humidity at 37 °C. Following daily bleaching, the specimens were thoroughly rinsed with tab water and gently brushed to remove bleaching agents. In groups II, III, IV, V, and VI, the bleached teeth were then restored with resin composite immediately, after 1, 7, 14, and 28 days following bleaching, respectively. After the elapsed time of each group, class V cavities (3x4x1.5 mm) were then prepared on both buccal and lingual aspects of each tooth. An occlusal margin of the prepared cavities was placed on enamel and a cervical margin was located on root surface. Teeth of each group were randomly treated with either etch-and-rinse adhesive (Single Bond 2; SB) or self-etching primer adhesive (Clearfil SE Bond X; SE) on buccal or lingual cavity. The bonding procedure was strictly followed the manufacturers' instruction. Subsequently, the cavities were bulk-filled with resin composite (Z250, 3M ESPE, St. Paul, MN, USA) followed by light-cured for 40 seconds (Spectrum™ 800, Dentsply Caulk, Milford, DE, USA). The restoration surface was polished using a flexible polishing disc (Sof-lex disc, 3M ESPE). The restored teeth were stored in distilled water at 37°C for 24 hours. All teeth were then thermocycled for 500 times between 5 and 55°C with a 30-second dwell time in each water bath.

After restoration, the root apices were sealed with adhesive resin and resin composite. Each tooth was coated with nail varnish, except 1 mm around the margin of the restoration. The restored teeth were immersed in 2% methylene blue dye solution for 2 hours and rinsed with running water. The teeth were longitudinally cut through the restored cavities with a slow-speed diamond saw (Isomet, Buehler, Lake Bluff, IL, USA) obtaining three slabs for each cavity (4 surfaces of each restoration to be examined). The dye penetration at the composite/tooth interface was evaluated under stereo microscope at 40x magnification (Zoom stereo microscope, SZ3060, OLYMPUS OPTICAL Co, LTP., Tokyo, Japan) for both the occlusal and cervical margins using the following scoring system: 0 = no dye penetration; 1 = dye penetration less than half the length of the occlusal/cervical wall; 2 = dye penetration more than half the length of the occlusal/cervical wall without reaching the axial wall; and 3 = dye penetration reaching the axial wall.

Kruskal-Wallis test was used to compare the scores of dye penetration between the elapsed times. The difference of the score arising from adhesive types was evaluated by Mann-Whitney U tests. The results with $p<0.05$ were considered statistically significant.

Ultrastructural examination

Twelve extracted human premolar teeth were used for examining the ultrastructural morphology of resin/tooth interface of resin composite restorations. The teeth were divided into six groups and assigned for the bleaching treatment as explained in the procedure of specimen preparation. All teeth were prepared for class V cavities and filled using the same method as described above. The teeth were vertically sectioned through the center of the restoration. The cut surface of each half was embedded using self-cured epoxy resin. The sectioned specimens were finished with ascending grades of SiC paper (up till 1200 grit) and polished with diamond paste down to 0.25 μm particle size. After each polishing, the sections were ultrasonicated under distilled water for 10 minutes. The sample surfaces were etched with 37.5% phosphoric acid for 30 seconds and subjected to dehydration in ascending concentrations of ethanol (50, 70, 90, 95% for 10 minutes each, and 100% for 20 minutes). The specimens were then stored in a desiccator containing silica gel for at least 24 hours following by gold sputter coated and observed under a scanning electron microscope (Leo1455VP, LEO (Karl Zeiss Group), Oberkochen, Germany).

Results

The microleakage median scores are presented in Table 2 and 3. At both occlusal and cervical walls, there was no statistically significant difference in dye penetration scores among the elapsed time after tooth bleaching groups (Kruskal-Wallis test $p>0.05$) regardless of adhesive systems used. However, group II and III showed relatively higher dye penetration scores compared to other groups. At cervical wall, SB performed significantly higher microleakage than SE (Mann-Whitney U tests, $p<0.05$) in all elapsed time and control groups.

Regarding the SEM observations, similar morphology of tooth-resin interface was found among elapsed time groups of each bonding system. The specimens of all groups exhibited close adaptation of resin composite to the occlusal cavity walls in both SB and SE groups. Close adaptation of resin composite to cavity walls of the specimens from an immediate group treated with SB and SE were shown in Figure 1 and Figure 2, respectively. Hybrid layers and resin tags were formed in dentin bonded with both SB and SE (Figure 3). Gaps were observed predominantly along the cervical dentin wall of the specimens treated with SB in groups II and III (Figure 4). Most of the specimens in SE group demonstrated close contact between resin and cervical wall (Figure 5).

Table 2: Frequency of microleakage score at resin/tooth interface of occlusal wall

	Score				Total
	0	1	2	3	surfaces
Single Bond					
Group I	39	9	0	0	48
Group II	32	9	3	4	48
Group III	42	4	1	1	48
Group IV	36	6	2	4	48
Group V	38	6	1	3	48
Group VI	44	4	0	0	48
Clearfil SE Bond					
Group I	10	31	1	6	48
Group II	26	11	8	3	48
Group III	41	7	0	0	48
Group IV	32	8	2	6	48
Group V	36	9	0	3	48
Group VI	44	4	0	0	48

Group I: control; Group II: immediate; Group III: 1 day; Group IV: 7 days; Group V: 14 days; and Group VI: 28 days.

Table 3: Frequency of microleakage score at resin/tooth interface of cervical wall

	Score				Total
	0	1	2	3	surfaces
Single Bond					
Group I	25	7	0	16	48
Group II	9	3	2	34	48
Group III	7	6	4	31	48
Group IV	11	8	1	28	48
Group V	16	4	2	26	48
Group VI	17	3	1	27	48
Clearfil SE Bond					
Group I	27	20	1	0	48
Group II	27	12	1	8	48
Group III	36	6	2	4	48
Group IV	34	8	3	3	48
Group V	33	9	2	4	48
Group VI	46	2	0	0	48

Group I: control; Group II: immediate; Group III: 1 day; Group IV: 7 days; Group V: 14 days; and Group VI: 28 days.

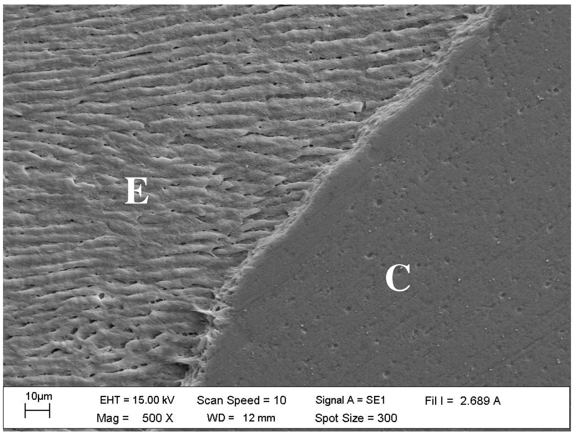

Figure 1 SEM photograph of the specimen from an immediate group treated with SB. Close adaptation of resin composite (C) to enamel cavity wall (E) is visible.

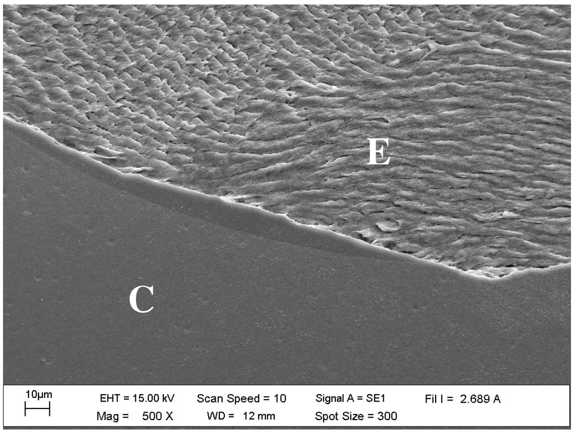

Figure 2 SEM photograph of the specimen from an immediate group treated with SE. Close adaptation of resin composite (C) to enamel cavity wall (E) is visible.

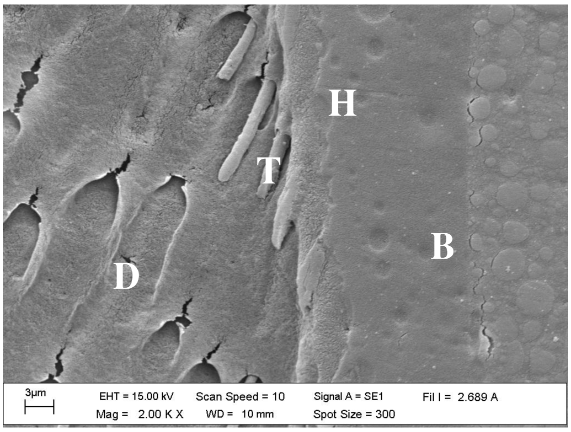

Figure 3 SEM photograph of the bonded interface between dentin cavity wall and adhesive system. Hybrid layer (H) and resin tags (T) can be seen. C: Resin composite. B: Bonding layer. D: Dentin.

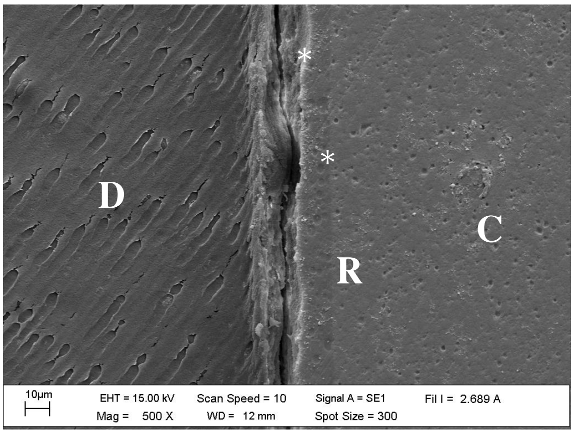

Figure 4 SEM photograph of the specimen from an immediate group treated with SB. Gaps (asterisks) are presented along the bonding resin (R) and dentin cavity wall (D). C: Resin composite.

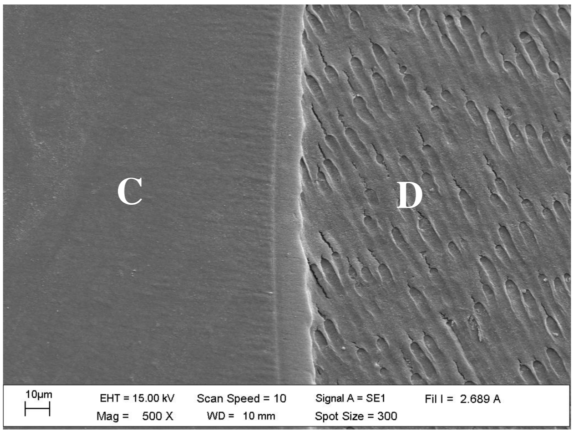

Figure 5 SEM photograph of the specimen from a 1-day group treated with SE. Close adaptation of resin composite (C) to dentin cavity wall (D) is visible.

Discussion

The hypothesis was rejected since the results of the present study demonstrated no significant effect of elapsed time on microleakage of resin composite restorations following tooth bleaching with 10% carbamide peroxide. It has been shown that the similar microleakage degree obtained from the immediately restored group and from 7 days after bleaching (Teixeira, et al., 2003). The bleaching agents containing 10% carbamide peroxide degrades into approximately 7% urea and 3% hydrogen peroxide. The main by-product decomposed from hydrogen peroxide is oxygen that interferes with the polymerization of bonding systems (Haywood & Robinson, 1997; Titley, et al., 1992). Titley, et al. (1992) has reported a granular and porous appearance with a bubbled appearance between the resin composite-enamel interface, that might imply the presence of oxygen degraded from bleaching solution. However, there has been demonstrated no differences in the amount of oxygen on bleached and nonbleached enamel surfaces (Perdigao, et al., 1998). This might contribute to non-significant microleakage performance in control and experimental groups at different post-bleaching time interval in the present study. According to the SEM observation in the present study, there is no granular or porous appearance. Moreover, a contemporary adhesive system, including SB and SE used in this study, provides favorable bonding effectiveness to tooth structure (van Meerbeek, et al., 2003). This was expected to compensate for the effect of elapsed time on microleakage after bleaching treatment.

Although there was no significant effect of elapsed time on sealing of resin composite restoration placed after bleaching procedure in this study, group II and III revealed comparatively high microleakage scores compared to other groups. This might imply an influence of post-bleaching time interval on bonding to tooth structure. Many studies have shown an adverse effect of adhesive application to dentin and enamel immediately and one day following bleaching; i.e., reduction in resin-tooth bond strength (Cavalli, et al., 2001), impaired sealing ability of resin composite restorations (Turkun & Turkun, 2004), decreased tooth surface hardness (de Freitas, et al., 2002; Metz, et al., 2007), and less resin penetration into bleached enamel (Da Silva Machado, et al., 2007). In addition to the bonding consideration, the stability of the tooth color changed by bleaching method should be concerned prior to placement of an adhesive resin restoration. Therefore, an adequate period between bleaching and bonding procedure is suggested to be one to three weeks (Cavalli, et al., 2001; Turkun & Turkun, 2004; Da Silva Machado, et al., 2007;).

SB demonstrated drastically higher microleakage score than SE at cervical wall regardless of elapsed time. Dentin comprises more organic substance and less mineral so that it can be easily affected by hydrogen peroxide-base material. Oxidizing effect from bleaching reaction possibly causes denaturation of organic matrix in dentin, producing morphologic alteration that could deteriorate the resin-dentin bond efficacy. In addition, etching the dentin with phosphoric acid might produce a porous zone at the hybrid layer base, resulting in a weak zone that is susceptible to degradation of the resin-dentin bond (Sano, et al., 1994).

On the other hand, the self-etching primer system provides less aggressiveness on conditioned dentin, thus allowing the bonding resin to completely penetrate the demineralized dentin. This system does not require separate etching, rinsing and drying procedures, and thus eliminate the risk of over-etching and over-drying (van Meerbeek, et al., 1998; Kubo, et al., 2001). A number of studies have reported that the self-etching system is able to prevent microleakage between restoration-tooth interface (Kubo, et al., 2001; Yazici, et al., 2002). Yoshida, et al. (2004) reported that the functional monomer (10-MDP) in SE creates chemical interaction with tooth substrate. An increased bonding effectiveness of self-etching primer may result from both micromechanical and chemical adhesion that would promote the bond durability and stability of adhesion.

According to the results of this study, the microleakage scores of cervical wall were generally higher than those of occlusal wall. It has been stated that dentin bonding is less reliable compared to enamel bonding because of the intrinsic characteristics of this substrate (Nakabayashi, 1982). The sealing as well as bonding of resin-enamel and resin-dentin might be affected by the differences in the chemical compositions between enamel and dentin. Fifty percent of the total volume of dentin is organic and water content compared with 12% of total volume for enamel (Roberson, et al., 2006). An exposure of collagen network is susceptible to hydrolytic degradation, leading to the reduction of bond integrity (Burrow, et al., 1996; Hashimoto, et al., 2000). This might explain the gaps along the dentin cervical wall.

Conclusion

Under the conditions of this study, the elapsed time after tooth bleaching did not significantly affect the microleakage of Class V resin composite restoration in association with two adhesives used. At cervical wall, SB performed significantly higher microleakage than SE in all elapsed time.

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