Effect of Prerestorative Home-bleaching on Microleakage of Self-etch Adhesives

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ABSTRACT

Background: Tooth bleaching has become a routine treatment due to patients' esthetic demands.

Purpose: The aim of this study was to evaluate how prerestorative home-bleaching affected microleakage of resin composite restorations bonded with etch-and-rinse and self-etch adhesives.

Materials and Methods: Fifty extracted human premolar teeth were used. The bleaching agent (10% carbamide peroxide) was applied to the buccal surface of each tooth for 6 hours a day for 2 weeks. The lingual surfaces of the same teeth received no application (control). The teeth were stored in artificial saliva. After 14 days, standardized Class V cavity preparations (2 mm high, 3 mm wide, and 2 mm deep) were made on the buccal and lingual surfaces with all margins in the enamel. They were randomly divided into five groups according to the adhesive systems: an etch-and-rinse adhesive (Single Bond [SB]), two two-step self-etch adhesives (Adper SE Plus [ASE] and One Coat [OC]), and two one-step self-etch adhesives (Adper Easy One [EO] and G-Bond [GB]). All adhesives were applied according to the manufacturers' instructions. The preparations were then restored using the same hybrid composite (Filtek Z250) in one increment and light-cured. The teeth were thermocycled (5/55°C, 1,000×) and immersed in dye, then sectioned, and dye penetration was scored. The data were analyzed using the Kruskal-Wallis and Mann-Whitney *U*-tests.

Results: Although statistically significant differences were found between the adhesive systems in the bleached teeth, no differences were observed in the control groups (non-bleached teeth). There were significant differences between SB/GB, SB/EO, SB/OC, and GB/ASE in the bleached teeth ($p < 0.05$). When comparing bleached and non-bleached teeth within each adhesive system, only SB and EO produced higher leakage scores when bleaching was applied. The other groups showed no difference in terms of bleaching ($p > 0.05$).

Conclusion: Prerestorative home-bleaching had an adverse effect on microleakage of SB and EO.

CLINICAL SIGNIFICANCE

The effect of prerestorative home-bleaching agents on microleakage of composite resin restorations differs according to the type of adhesive material used.

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INTRODUCTION

Bleaching has gained popularity because of its ease of application, cost effectiveness, safety, and availability to all patients. Bleaching techniques may be classified as in-office and home bleaching.[1] Although many different types of in-office bleaching products and methods have been developed, the use of home bleaching is widespread and remains popular. Carbamide peroxide at varying concentrations is the most commonly used agent for home bleaching and has been shown to be effective in clinical studies.[2–4] However, teeth may require restorative treatments such as diastema closures, the application of an orthodontic device, or cavity preparations for fillings after the bleaching procedure. In the literature, most of the studies evaluated the effects of bleaching agents on bond strength of restorations and usually reported that immediate bonding of composite resins to bleached enamel results in a decrease in bond strength.[5–7] This has been attributed to the adverse interaction of residual active chemicals of bleaching agents and monomer polymerization.[8] Therefore, it is generally suggested that adhesive restorative procedures should be postponed for 2 weeks after any bleaching procedure.[9,10] Several studies concluded that residual oxygen removal by saliva results in a complete reversal of the reduced enamel bond.[9,11] Basting and colleagues[9] reported that concentrations varying from 10% to 22% carbamide peroxide agents cause no differences in shear bond strength of enamel to an adhesive system after 15 days of storage in artificial saliva.

Recently, dentin adhesives have been developed to simplify the three clinical steps: etching, priming, and bonding. One type combines the primer resin with the adhesive resin into a single component, and acid etching is applied separately, which is called the etch-and-rinse adhesive system. The other type is the self-etch adhesive system, which involves either two-step adhesives, requiring an additional bonding step, or all-in-one adhesives, combining the etching, priming, and bonding into a single-step application.[12] Comparison of etch-and-rinse and self-etch systems in terms of microleakage has been well documented.[13,14] However, little information is available in the literature regarding the influence of bleaching agents on the microleakage of these adhesive systems.[15,16] It has been reported that the retention of bonded resin composite to enamel treated with carbamide peroxide bleaching agents might be affected by the type of adhesive system selected.[16]

Although several studies have focused on bonding to bleached enamel,[17–23] only a few studies have evaluated the effect of bleaching on microleakage of restorations, and most of them assessed these effects on existing restorations.[24,25] As little is known about the bleaching effect prior to restoration placement on microleakage,[26,27] the aim of this in vitro study was to evaluate how prerestorative home bleaching affects microleakage of composite resin restorations bonded with etch-and-rinse and self-etch adhesive systems.

MATERIALS AND METHODS

Fifty human premolar teeth extracted for orthodontic reasons were used for the study. The teeth were examined under ×2 magnification and determined to be caries free and without fractures or cracks. After surface debridement with a hand-scaling instrument and cleaning with a rubber cup and slurry of pumice, the teeth were stored in saline.

The labial surface of each tooth was treated with a home bleaching agent, Opalescence PF (10% carbamide peroxide, Ultradent, South Jordan, UT, USA), for 6 hours a day on 14 consecutive days. Remnants of the bleaching gel were removed with running water after each single application. Lingual surfaces of the teeth were not bleached and served as control. To simulate oral conditions, the bleached teeth were stored in artificial saliva (1.5 mmol/L $CaCl_2$, 1.0 mmol/L KH_2PO_4, and 50 mmol/L NaCl, pH 7.0) at 37°C between bleaching treatments and prior to restoration. After 14 days, standardized Class V cavity preparations were prepared on both the buccal and lingual surfaces of each tooth. The cavities were made with a cylindrical diamond bur (Diatech, Swiss Dental, Heerbrugg, Switzerland) in a water-cooled high-speed handpiece and were approximately 2 mm high, 3 mm wide, and 2 mm deep. A new bur was used for every five preparations. All margins were in enamel. After completing the preparations, the teeth were randomly assigned to one of 5 groups of 10 teeth according to the adhesive systems. The adhesive systems used in the study are listed in Table 1 and were used strictly according to the manufacturers' instructions. Filtek Z250 composite, shade A2 (3M ESPE, St. Paul, MN, USA) was placed in one increment and cured for 40 seconds using a Quartz-tungsten-halogen light (Hilux, Benlioglu, Ankara, Turkey). The output of the curing unit was measured with a curing radiometer to ensure a constant value of light intensity of 550 mW/cm^2. The same operator performed all cavity preparations and restorations. All restorations were finished with finishing diamond burs (Diatech) and polished with a graded series of Sof-Lex disks (3M ESPE). The restored specimens were stored in distilled water at room temperature for 24 hours. The teeth were then submitted to 1,000 thermal cycles with temperatures between 5°C ± 2°C and 55°C ± 2°C, and with a dwelling time of 30 seconds. Following thermocycling, the specimens were coated with nail varnish, leaving a 1-mm window around the cavity margins. The teeth were then placed in a solution of 0.5% basic fuchsin dye for 24 hours at room temperature. Following dye exposure, the teeth were rinsed with distilled water and embedded in self-curing clear orthodontic resin (Dentsply, Caulk). Embedded specimens were sectioned longitudinally through their centers in the buccolingual plane using a water-cooled, slow-speed diamond saw. The specimens were randomly examined by two observers unaware of the adhesive system used by viewing them under a stereomicroscope with ×40 magnification.

The worst value recorded for each section was selected for analysis. Marginal penetration was scored on a 0–4 rank scale as follows: 0 = no evidence of dye penetration at the tooth/restoration interface; 1 = dye penetration up to one-third of cavity depth; 2 = dye penetration up to two-thirds of cavity depth; 3 = dye penetration to full depth of cavity depth; 4 = dye penetration into the axial wall of the cavity. The data were subjected to non-parametric Kruskal-Wallis and Mann-Whitney *U*-tests.

RESULTS

The enamel microleakage scores are shown in Table 2. Although significant differences were found between the adhesive systems in bleached teeth, no differences were observed in the control groups (non-bleached teeth). There were significant differences between Single Bond/G-Bond (SB/GB), SB/Adper Easy One (SB/EO), SB/One Coat (SB/OC), and GB/Adper SE Plus (GB/ASE) in the bleached teeth ($p < 0.05$), and SB had the highest leakage scores (Table 3).

Comparison of the bleached versus non-bleached teeth showed significant differences only in SB and EO ($p < 0.05$) (Table 4). SB and EO demonstrated higher leakage scores when bleaching was applied. The other groups showed no difference in terms of bleaching ($p > 0.05$).

DISCUSSION

The popularity of bleaching has increased in recent years. This has led to a greater use of bleaching agents in daily practice; thereby, the clinician should be aware of the effects of these agents on tooth structure. This study assessed the prerestorative home bleaching affects on composite resin

TABLE 1. ADHESIVE SYSTEMS, MANUFACTURERS, AND APPLICATION MODES.

Adhesive systems	Composition	Mode of application
Single Bond (SB) (etch-and-rinse adhesive) 3M ESPE, St. Paul, MN, USA Batch # 2007036	Bis-GMA, dimethacrylates, HEMA, water, ethanol, PAA, photoinitiator	Acid etch for 15 seconds with phosphoric acid. Rinse for 10 seconds. Blot dry. Apply two consecutive coats of adhesive for 15 seconds, air thin for 5 seconds and light cure for 10 seconds.
Adper SE Plus (ASE) (two-step self-etch adhesive) 3M ESPE, St. Paul, MN, USA Batch # 70-2010-5421-3	Liquid A: Water, HEMA, Surfactant, Pink Colorant Liquid B: UDMA, TEGDMA, TMPTMA, HEMA, MHP, Bonded zirconia nanofiller, camphorquinone	Apply Liquid A to all fissures. Scrub Liquid B into the entire wetted surface for 20 seconds and air dry for 10 seconds to evaporate water. Apply second coat of Liquid B, air thin lightly and light-cure for 10 seconds.
One Coat (OC) (two-step self-etch adhesive) Coltene, Whaledent, Switzerland Batch # 770	Primer1:Water, acrylamidosulfonic acid, hydroxyethyl methacrylate, glycerol mono-and dimethacrylate, polyalkenoate methacrylized Bond 2: HEMA, glycerol mono-anddimethacrylate, UDMA, polyalkenoate methacrylized	Apply Primer 1 to enamel and dentin surfaces and rub for 20 seconds, then air dry lightly for 2 seconds. Apply Bond 2 to enamel and dentin surfaces and rub for 20 seconds, then air dry lightly for 2 seconds. Light cure for 20 seconds.
Adper Easy One (EO) (one-step self-etch adhesive) 3M ESPE, St. Paul, MN, USA Batch # 318383	HEMA, Bis-GMA, methacrylated phosphoric esters, 16hexanediol dimethacrylate, methacrylate functionalized polyalkenoic acid, finely dispersed bonded silica filler with 7 nm primary particle size, ethanol, water, camphorquinone, stabilizers	Apply adhesive to tooth surface for a total of 20 seconds. Dry the adhesive for 5 seconds. Light cure for 10 seconds.
G-Bond (GB) (one-step self-etch adhesive) GC, Co, Tokyo, Japan Batch# 0007131	4-MET, phosphate ester monomer, UDMA, water, acetone, silicafiller, photo initiator	Actively rub for 5 seconds, air dry strongly to homogeneous, slightly shiny surface, light cure for 10 seconds.

4-MET = 4-metacryloxyethyl trimellitate; Bis-GMA = bisphenol glycidyl methacrylate; HEMA = 2-hydroxyethyl methacrylate; MHP = methacrylated phosphates; TEGDMA = triethyleneglycol dimethacrylate; TMPTMA = hydrophobic trimethacrylate; UDMA = urethane dimethacrylate.

restorations bonded with etch-and-rinse and self-etch adhesive systems in terms of microleakage. In the present study, whereas the pre-restorative bleaching increased the microleakage of composite restorations bonded with Single Bond and Adper Easy One, the rest of the restorations, bonded with GB, ASE, and One-Coat, were not affected by bleaching. There are only a few studies evaluating the bleaching effect on microleakage.[24–26] Crim[26] evaluated the effect of bleaching on the microleakage of subsequently placed Class V composite resin restorations. He concluded that

TABLE 2. ENAMEL MICROLEAKAGE SCORES.

		Microleakage scores				
Adhesive systems		**0**	**1**	**2**	**3**	**4**
Single Bond	Bleached	2	4	1	1	2
	Non-bleached	9	0	1	0	0
Adper SE Plus	Bleached	2	7	1	0	0
	Non-bleached	6	4	0	0	0
One Coat	Bleached	6	4	0	0	0
	Non-bleached	9	1	0	0	0
Adper Easy One	Bleached	6	3	1	0	0
	Non-bleached	10	0	0	0	0
G-Bond	Bleached	8	2	0	0	0
	Non-bleached	9	1	0	0	0

TABLE 3. *P*-VALUES FOR COMPARISON: ADHESIVE VERSUS ADHESIVE FOR BLEACHED ENAMEL.

	Adhesive systems				
	Single Bond	**Adper SE Plus**	**One Coat**	**Adper Easy One**	**G-Bond**
Single Bond		0.244	0.023	0.038	0.005
Adper SE Plus			0.060	0.131	0.008
One Coat				0.861	0.342
Adper Easy One					0.300

The underlined *p*-values are <0.05 and indicate significant difference.

TABLE 4. *P*-VALUES FOR COMPARISON BLEACHED VERSUS NON-BLEACHED ENAMEL FOR EACH ADHESIVE SYSTEM.

	Adhesive systems				
	Single Bond	**Adper SE Plus**	**One Coat**	**Adper Easy One**	**G-Bond**
Bleached versus non-bleached	0.004*	0.06	0.131	0.030*	0.542

* indicates statistical significance ($p < 0.05$).

prerestorative bleaching did not affect the marginal seal of subsequently placed restorations. In another in vitro study, the effects of pre- and postoperative bleaching with 10% carbamide peroxide on marginal leakage of amalgam and resin composite restorations were investigated,[28] and it was found that marginal leakage of resin composite restorations increased in both pre- and postoperatively bleached groups, but marginal leakage of amalgam restorations showed no alterations. In two recent studies, no adverse effect of bleaching on microleakage of composite restorations was reported.[24,25] However, in these studies, bleaching was performed after the placement of restorations.

The reduced bond strength values obtained in bleached teeth may be explained by the poorly defined etch-patterns and the presence of polymerization-inhibiting residual oxygen observed in the structure of bleached teeth.[8,29] Thus, it might have been expected that the etch-and-rinse adhesive Single Bond, which uses separate acid etching, would result in the least leakage with a more pronounced etch pattern. However, we obtained the opposite results. This may be related to the structure of bleached enamel. It is known that bleaching agents can alter the microhardness, roughness, and morphology of the dental enamel surface.[30,31] Acid etching of the bleached enamel surface causes loss of the prismatic form and the enamel appears overetched.[32] The phosphoric acid might cause excessive etching and this might contribute to increased leakage. Cadenaro and colleagues[33] found that etching and rinsing procedures were not able to eliminate residual oxygen from the bleached surface. Moreover, Adper Easy One is a mild self-etch adhesive with a pH of 2.7, the highest pH of the adhesives tested. This adhesive might not have been able to remove the residual oxygen or might have caused a mild etching effect, and this might have contributed the higher leakage scores on bleached enamel surfaces compared to non-bleached ones.

There are contradictory findings regarding the relationship among the bonding capacity of adhesives to bleached tooth surfaces and their solvent type. An in vitro study evaluated the effect of three dentin adhesives on the bond strength of a composite to enamel that was treated with a 10% carbamide peroxide bleaching system.[19] Although no significant differences were observed in the alcohol-based adhesive's bond strength to bleached and unbleached enamel, the acetone-based adhesive's bond strength to bleached enamel was decreased. It has been stated that alcohol-based adhesive systems might minimize the inhibitory effect of oxygen because of the interaction of alcohol and oxygen.[34] In another study, it was reported that ethanol or acetone-based adhesive systems counteract the effect of whitening because of their water-clearing effect.[35] Lai and colleagues[36] found a reduction in bond strengths of both acetone and alcohol-based adhesive resins after bleaching procedures. Similar to this finding, Nour El-din and colleagues[20] determined the bond strength of Single Bond, an ethanol-based adhesive, and One Step, an acetone-based adhesive, to bleached enamel and reported significantly lower bond strength values compared to the non-bleached controls. Another study stated that bond strength values were lower in bleached than in unbleached teeth, but did not differ between the acetone-based or ethanol-based adhesives.[37] Kimyai and colleagues[38] also reported that the use of Single Bond (water/ethanol based) did not reverse the adverse effects of the bleaching agent. In a recent study, neutral sodium fluoridated and non-fluoridated whitening products were compared in terms of their effects on human enamel/resin bond strength.[21] A decrease in enamel bond strength using an ethanol-based adhesive, Optibond Solo Plus, was determined. We also found that restorations bonded with SB and EO showed higher leakage when the teeth were preoperatively bleached. EO also contains water/ethanol like SB. The oxygen inhibition layer decreases the ability of the ethanol-based adhesive to penetrate enamel.[21]

As the results obtained are based on in vitro findings, clinical studies with different concentrations of home-bleaching agents and different adhesives should be conducted with brushing and dentifrice effects taken into consideration.

DISCLOSURE

The authors do not have any financial interest in the companies whose materials are included in this article.

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