Original Study

EFFECT OF BLEACHING ON ENAMEL BONDING WITH DIFFERENT ADHESIVE PROTOCOLS & NANOHYBRID COMPOSITE

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ABSTRACT

Aim: To evaluate the effect of bleaching on the shear bond strength of two different adhesive systems and nanohybrid composite resin to enamel.

Materials & Method: Forty enamel specimens were prepared from human premolar teeth and divided into four groups on the basis of the type of adhesive protocol (total-etch or self-etch adhesive systems) used. Twenty of the specimens were bleached with 40% hydrogen peroxide and divided into two groups for further adhesive procedures. The remaining specimens that were not bleached were considered to be the control group and were restored using the two different adhesive systems. After completion of the adhesive procedures, nanohybrid composite resin cylinders (2 mm × 3 mm) were bonded to the enamel surfaces. All specimens were then subjected to a shear bond strength test on a universal machine, and the fracture patterns were assessed using a stereomicroscope.

Results: The mean shear bond strength was significantly lower in the groups that underwent bleaching compared with the control groups that were not subjected to bleaching ($\alpha = 0.05$). Moreover, greater shear bond strength was observed when using self-etch adhesives compared with total-etch adhesives.

Conclusion: The shear bond strength between composite resin and enamel decreased upon bleaching. Moreover, it was significantly better when self-etch adhesive systems were used.

Key words: Adhesives, Bond strength, Bleaching, Composite, Nanohybrid, Self etch, Total etch.

Introduction

Tooth discoloration, one of the most common esthetic enigma encountered in dentistry can be caused by a number of extrinsic, intrinsic factors,[1,2] and the treatment options include tooth bleaching at home or in the dental clinic. Dental bleaching is defined as the process of removing stains or pigments from teeth by the application of chemicals, has been carried out in dental clinics for many years. It is considered to be the most conservative and well-accepted treatment option for discolored teeth as it does not require any reduction in tooth structure.[3-6] Bleaching agents typically include strong oxidizing agents such as hydrogen peroxide that whiten the teeth by decomposing into free oxygen radicals that break down larger pigmented molecules accumulated on the teeth into smaller and less pigmented molecules.[7,8]

Bleaching agents may also affect the bonding between resin restorations and the tooth substrate. A previous study reported that the mean shear bond strength between resin and bleached enamel was significantly lower than that between resin and unbleached enamel, and this could be due to the presence of active chemicals from the bleaching agents or residual oxygen that inhibits resin polymerization and lead to increased resin porosity.[9] However, this was contradicted by other studies that reported no difference in mean shear bond strength between resin and bleached and unbleached enamel.[10-12]

Despite of the possibility of side effects of bleaching treatment, there are few studies that restored the teeth with different adhesive protocols for showing the effect of bleaching on the bond strength to the teeth.[13]

Vast improvements in adhesive systems have directly affected composite resin restorations, resulting in highly predictable levels of clinical success. Self-etch adhesive systems are currently the most popular option as they can demineralize and infiltrate the tooth surface to the same depth, thus decreasing the application time and technique sensitivity.[13-15] Moreover, previous studies have reported that patients treated with self-etch adhesives exhibited less postoperative sensitivity.[16,17] Such adhesives can be bought as two-step (where the self-etching primer and adhesive resin are provided separately) or one-step (where the self-etching primer and adhesive resin are combined into a single solution) systems.[15]

Adhesives must be tested carefully before clinical use,[18] and the three-step etch process has been shown to result in the best adhesion durability. Therefore, inclusion of an additional step that uses an adhesive resin layer that is solvent free has a neutral pH, is hydrophobic, and produces extremely desirable results with regard to bonding.[13]

Various adhesive systems may exhibit different bonding strengths with the enamel as it is more mineralized than the dentin, which contains a considerable amount of organic material and water. Therefore, the aim of the current study was to examine the influence of bleaching on the shear bond strength of two different adhesive systems. The null hypothesis was that bleaching would have no effect on the shear bond strength.

Materials & Method

The study This study included forty recently extracted,sound human premolar teeth collected from private practices in taif over a period of four months. The study protocol was approved by the Ethicsal committee of the University of Medical Sciences (Ref # 910709),Taif university,Taif. The teeth were scaled with a periodontal scaler to remove any organic debris, cleaned using water/pumice slurry, and then stored in distilled water at 37 °C in an incubator until further use.

The roots of the teeth were cut at the cemento-enamel junction using a low-speed diamond bur under a water coolant and mounted in autopolymerizing acrylic resin (Acrostone (A), Anglo-Egyptian Company,Hegaz, Cairo, Egypt, Batch No.505/04) such that the buccal aspect was positioned for surface treatment and composite bonding. After polymerization of the embedding resin, the buccal aspect of the teeth were ground to form a flat surface using wet 150 grit silicon carbide paper, polished using 400 and 600 grit silicon carbide paper for 10 seconds so as to form a uniform rough surface and then randomly divided into four groups (n = 10) as follows:

- Group A1: specimens restored using total-etch adhesive without bleaching.
- Group A2: specimens restored using total-etch adhesive after bleaching.
- Group B1: specimens restored using self-etch adhesive without bleaching.
- Group B2: specimens restored using self-etch adhesive after bleaching.

The enamel surfaces of the specimens in groups A2 and B2 were dried with cotton pellets and bleached using 40% hydrogen peroxide (Opalescence® Boost PF 40% In-Office Power Bleach Ultradent products INC, USA) at 100% humidity and 37 °C temperature for 40 seconds. The bleaching agent was then removed using a soft toothbrush under running tap water, and the samples were stored in distilled water at 37 °C.

The enamel surfaces of etch and rinse groups were dried using compressed air (oil free and moisture free) for 5 seconds. Thereafter, a syringe needle tip was used to place etchant (Scotch bond TM Multipurpose,3M,ESPE,USA) on the restricted surface of the specimen through a holed masking tape applied on enamel surface for 15 seconds. The surfaces were washed using distilled water for 10 seconds and dried using oil-free compressed air until a white chalky appearance was seen. The adhesive systems were then applied on the respective samples as per the manufacturer's instructions.

This study used an etch-and-rinse adhesive (Adper scotchbond 1 XT, 3M, ESPE,USA) and a one-step self-etch adhesive (Adper Easy One, 3M, ESPE,USA), both of which were bonded to the enamel and light-cured using an LED unit for 10 seconds (BG-light-LTD, 4002 Plovdiv, 430–490 nm, Bulgaria).

Following application of the adhesive systems following manufacturer instructions, a nanohybrid composite resin (Filtek Z350 XT, 3M ESPE, St. Paul, USA, N706303) was applied using Teflon tube with an inner diameter of 2 mm and a height of 3 mm and attached to the prepared surfaces in increments of 1.5 mm each. The resin was light-cured for 40 seconds, and the mold was carefully removed. The prepared specimens were then stored in an incubator at 37 °C for 24 hours.

The specimens were mounted on a universal testing machine (Lloyd universal testing machine (model LRX plus II, Fareham, England) (Figure 1), at a cross-head speed of 0.5 mm/min and a load of 6 kg was applied.A parallel knife-edge shearing device was aligned over the bonded surface near the interface, and the force was applied until failure. The shear bond strength, expressed in mega-Pascals (MPa), was defined as the ratio of the fracture load to the bonded area.

Figure 1: Specimens mounted on the universal testing machine for the measurement of shear bond strength

The failure modes were observed using a stereomicroscope (Stereo microscope, Nikon, SMZ-1O-Japan) at a magnification of 8×. Three main types of failure were observed: (a) type 1: adhesive failure between the bonding resin and the dental substrate; (b) type 2: cohesive failure in the bonding resin; and (c) type 3: cohesive failure in the dental substrate.

Statistical analysis

The differences in mean shear bond strength (MPa) were tested using analysis of variance, followed by Tukey's post hoc test and an independent sample t-test when necessary. All statistical tests were two sided, and the significance level was set at $p < 0.05$. The Statistical Package for Social Science version 17 (SPSS Inc., Chicago) was used for all analyses.

Results

The null hypothesis, which was that bleaching would have no effect on the shear bond strength, was rejected. The results of this study showed that the specimens in the groups that had undergone bleaching (A2 and B2) exhibited lower shear bond strength compared with the controls that had not been subjected to bleaching (A1 and B1), and this

difference between the groups was statistically significant ($\alpha = 0.05$) [Table 1]. A comparison of the bond strength between the total-etch and self-etch adhesive systems and the enamel has been shown in Table 1. Greater shear bond strength was observed with self-etch adhesives compared with the total-etch adhesives, irrespective of whether the specimens had undergone bleaching or not. These differences were statistically significant in both the control and experimental groups.

Samples	Mean (MPa)	SD	SE of Mean	Rank	*p* value
Group A1	8.91	±0.76	0.24	D	<0.001*
Group A2	6.40	±0.74	0.23	C	
Group B1	13.48	±0.58	0.18	B	
Group B2	11.08	±0.67	0.21	A	

Table 1: Comparison of the mean shear bond strength (MPa) between the control and experimental groups of the tested adhesives.

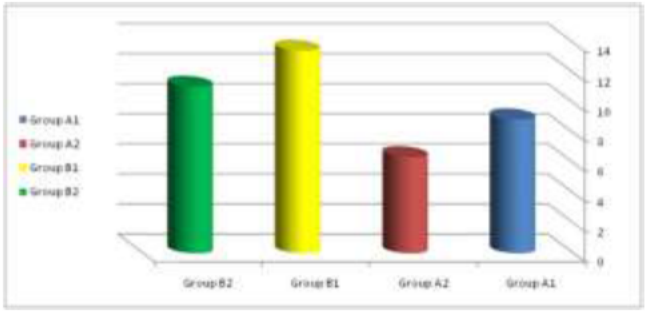

Figure 2: Bar chart of the mean shear bond strength (MPa) in the control and experimental groups of the tested adhesives

The most common type of failure observed at the bonded resin composite and enamel surface interfaces were adhesive in nature, with 100% of specimens treated with the total-etch adhesive system and 75% of the specimens treated with the self-etch adhesive systems exhibiting it. Cohesive failures were observed only in specimens treated with the self-etch adhesive systems. [Table 2]

Failure modes	Total-etch Groups (%)	Self-etch Groups (%)
Type 1: Adhesive failure between the bonding resin and the dental substrate	20(100%)	16(75%)
Type 2: Cohesive failure in the bonding resin	0(0%)	4(25%)
Type 3: Cohesive failure in the dental substrate	0(0%)	0(0%)

Table 2: Frequency and Type of bond failure.

Discussion

The current in vitro study examined variations in the shear bond strength between a nanohybrid resin composite and the human enamel upon bleaching and when treated with two different adhesive systems. Following bleaching using hydrogen peroxide, the treatment protocol typically includes restoration of fractured teeth or replacement of earlier aesthetic restorations. Currently, bleaching systems may vary with regard to the concentrations of the active bleaching agents (hydrogen or carbamide peroxide) and the application techniques. Vital tooth bleaching using carbamide and/or hydrogen peroxide has been recognized as a conservative and safe procedure for the treatment of tooth discoloration.[3] Various studies have reported an association between bleaching agents and the bond strength of composite resins to the enamel surface, and this could be explained to a certain degree by the changes observed in the chemical and morphological structure of the enamel.[20]

The bleaching agent used in this study was hydrogen peroxide, and this was followed up with either the total-etch or the self-etch adhesive system. The results of this study showed that the specimens that had undergone bleaching exhibited lower mean shear bond strength compared with the specimens that did not undergo bleaching, irrespective of the adhesive system used. This decrease in bond strength could be attributed to the morphological and chemical alterations of the substrate, including the presence of remnants of the bleaching gel and residual oxygen in the enamel, that may have resulted in inadequate polymerization of the adhesive systems.[13,20]

In the preceding research on this subject has showed that there is no agreement on decreased bond strength caused by bleaching or on waiting time for the placement of adhesive restorative material after these treatments.

The failure of the adhesive procedure after bleaching could also be explained by the presence of residual oxygen from the bleaching agent in the enamel surface.[21] The results of the current study were in agreement with previous evidence that showed that bleaching of the enamel surface adversely affected the bond strength of adhesive materials.[20]

In the present study, the bond strength between the composite resin restoration and the enamel surface was higher in the self-etch adhesive group (B1) compared with the total-etch adhesive group (A1). Moreover, upon comparison of the total-etch adhesive system (A2) and the self-etch adhesive systems (B2), the latter was seen to exhibit greater shear bond strength between the composite material and the enamel surface after bleaching. The lower bond strength observed in the total-etch adhesive system could be attributed to the inclusion of solvents and alcohol that evaporate rapidly in its composition.[22] In contrast, the self-etch adhesive system contains water, organic solvents, and diluents that can easily penetrate into the tooth tissue.[23]

The improved bonding capability observed in all-in-one adhesives can be attributed to their advanced composition,

which includes hydrophilic and hydrophobic monomers, solvents, water, and additives.[24,25]

The adhesive layer promotes an elastic zone that improves the capacity when composite resin shrinks.[26,27] Functional monomers contained within the adhesives react with Ca+2 from the tooth to form apatite crystallites within the partially demineralized hybrid layer, resulting in deposition of insoluble calcium salt.[28,29] The bond effectiveness of self-etch adhesives can be attributed to this chemical interaction between the hydroxyapatite and the functional monomers present in the adhesive.[30]

Examination of debonded samples and analysis of the bond failure types with the help of a stereomicroscope showed that the most common failures were adhesive in nature and occurred at the resin composite – enamel surface interfaces.These could be explained by the presence of weak links between the resin composite and the enamel surface, caused by bleaching of the adhesive materials. The least common type of failures was cohesive in nature, and this was in agreement with Nour El-din *et al*. who also reported observing adhesive failures in all of the specimens included in their study.[22]

Further studies and long-term clinical evaluations are necessary in order to assess the effect of aging on the shear bond strength between enamel and dentin after bleaching.

Conclusion

The results of this study showed that the shear bond strength decreased significantly when the composite resin was bonded to bleached enamel. Moreover, the bonding of the composite resin to enamel was found to be significantly better when using a self-etch adhesive system.

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