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Effects of Internal Bleaching on Microtensile Bond Strength of a Former Veneer Composite to Tooth Enamel

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Abstract

Background: At present, combined provision of direct composite restorations and dental bleaching has become increasingly popular to meet the esthetic demands of patients. This study aimed to assess the effect of internal bleaching on microtensile bond strength of composite to freshly veneered enamel.

Methods: In this *in vitro* experimental study, 50 sound extracted human premolars were randomly divided into five groups (n=10). All teeth received composite veneers. Two groups underwent no further intervention and were subjected to measurement of microtensile bond strength of composite to enamel 24 *hr* and one week after the veneering. The remaining three groups underwent internal bleaching. Group 3 underwent bleaching one month after the veneering, and microtensile bond strength was measured after 24 *hr*. In groups 4 and 5, bleaching was performed immediately after the veneering. Microtensile bond strength was measured after 24 *hr* in group 4 and after one month in group 5. Data were analyzed using one-way ANOVA.

Results: All the groups were not significantly different regarding the mean bond strength (p=0.110), but they were significantly different in terms of the mode of failure (p=0.01) such that the mode of failure was mainly adhesive in the three bleached groups.

Conclusion: Internal bleaching after composite veneering has no significant effect on microtensile bond strength of composite to the enamel.

Keywords: Analysis of variance, Bicuspid, Dental enamel, Esthetics, Humans

Introduction

The demand for esthetic dental treatments is growing worldwide (1). Anterior teeth play a fundamental role in smile esthetics and their color, shape, structure, and alignment can greatly impact the smile attractiveness. Direct composite veneers are commonly used for the correction of tooth discolorations, rotated teeth, coronal fractures, diastema, discolored restorations, palatally positioned teeth, lateral incisor missing, abrasion and erosion (2). Tooth discoloration may occur due to a number of reasons. Extrinsic discoloration may occur as the result of exposure of tooth structure to pigments in colored foods and drinks, and smoking. Intrinsic discoloration often occurs in non-vital teeth or as the result of medication intake. Discolored non-vital teeth, particularly those that have undergone endodontic treatment, commonly require esthetic dental treatments. Tooth bleaching involves the use of chemical agents such as hydrogen peroxide, carbamide peroxide and sodium perborate to oxidize the organic pigments and lighten the tooth shade. It can be performed internally or externally (3).

Internal bleaching is a commonly applied successful modality for the treatment of discolored non-vital teeth. However, the peroxide produced in the process of bleaching may remain in the tooth structure and cause problems. These problems may induce reduction in bond strength of composite resin to bleached enamel and dentin, and microleakage (4,5). Application of sodium ascorbate for neutralizing the oxygen produced following bleaching procedure has been recommended by several studies (6,7) .

Some researchers (8-10) claim that the longer the time interval between the internal bleaching process and provision of composite restorations (which should be minimally two weeks), the lower the adverse effects of peroxide on bond strength would be. However, in some cases, the patients urgently demand esthetic dental treatments and a 2-week delay is not acceptable for them. Thus, changing the order of procedures and performing the composite veneering at first and conduction of non-vital dental bleaching after that (with no time restriction) may be helpful. This study aimed to assess the effect of internal bleaching on microtensile bond strength of composite to freshly veneered enamel.

Materials and Methods

This in vitro experimental study evaluated 50 human premolars extracted as part of orthodontic treatment. The study was approved by the ethics committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RIDS.REC.1396.530). The sample size was calculated to be 10 in each group (a total of 50) according to a study by Uysal *et al* (11) assuming alpha=0.05, beta=0.1, power of 90% and mean bond strength of 9 MPa using one-way ANOVA feature of PASS II software.

The inclusion criteria were sound human premolars with no caries, cracks, defects, fluorosis or hypoplastic lesions confirmed by stereomicroscopic assessment (C-DS; Nikon, Tokyo, Japan) at ×50 magnification. The teeth had been extracted within the past 5 months (12). The teeth were selected using convenience sampling.

The organic residues were removed using a periodontal scaler, and the teeth were cleaned with pumice paste and water. They were immersed in 0.5% chloramine T solution (Merck, Hohenbrunn, Germany) for one week and were then transferred to distilled water at 4*°C* and remained there until one week prior to the experiment according to ISO/TS 11405 (13). The teeth were then immersed in artificial saliva composed of 1.5 *mmol/L* Ca, 50 *mmol/L* KCL, 0.9 *mmol/L* PO4 and 20 *mmol/L* Trihydroxy methyl aminomethane at a pH of 7. The artificial saliva was refreshed daily. For the purpose of standardization of surface properties and the smear layer according to ISO/TS 11405, the buccal surface of the teeth was polished with 600-grit silicon carbide abrasive papers under running water for 60 *s*. The teeth were then randomly divided into 5 groups (n=10) as follows:

Group 1. The enamel surface was veneered with composite, and no bleaching was performed in this group. The bond strength was measured after 24 *hr*. This group was served as the control group.

Group 2. The enamel surface was veneered with composite, and no bleaching treatment was performed in this group. The bond strength was measured after one week.

Group 3. Internal bleaching was performed 4 weeks after composite veneering in this group. The bond strength was measured after 24 *hr*.

Group 4. Internal bleaching was performed immediately after composite veneering, and the bond strength was measured after 24 *hr*.

Group 5. Internal bleaching was performed immediately after composite veneering and the bond strength was measured after one month.

For composite veneering of the samples, they were first etched with 35% phosphoric acid (Scotchbond etchant; 3M ESPE, St. Paul, MN, USA) for 30 *s*; they were then rinsed with distilled water for 10 *s* and dried with air spray. Adper Single Bond 2 (3M ESPE, St. Paul, MN, USA) was applied in two layers and dried with air spray for 5 seconds in order to evaporate the solvent. It was then light cured for 20 *s* using a light-curing unit (Demetron, Kerr, CA, USA) with a light intensity of 800 mW/cm^2, checked by a radiometer (SDI Co, Victoria, Australia) after preparation of each five specimens. Z250 microhybrid composite (3M ESPE, St. Paul, MN, USA) was applied in 4 *mm* thickness incrementally (two increments each having 2 *mm* thickness) and light-cured for 40 *s*.

The walking bleaching technique was adopted for internal bleaching of the teeth. The access opening was carried out using a round diamond bur in such a way that sufficiently reach the incisal and lateral extends of the pulp chamber. An attempt was made to prepare the opening of the teeth as similar as possible. The canal orifice was sealed with glass ionomer Fuji II (GC, Tokyo, Japan) with a thickness of 2 *mm*, and 35% hydrogen peroxide gel (Opalescence; Ultradent Products, Inc. St Louis MO, USA) was applied in the pulp chamber.

The pulp chamber was then sealed with Coltosol (ARIA DENT co, Tehran, Iran). The teeth were immersed in artificial saliva at 37°*C* for 24 *hr*. They were then longitudinally sectioned in Y and X axes using a Mecatome (Tzolia, France) with a disc with 1 *mm* diameter to obtain samples with a cross-sectional area of 1 mm^2. The samples were mounted in a microtensile tester (Bisco, Schaumburg, Illinois U.S.A.) and subjected to a load at a crosshead speed of 1 *mm/min* until failure. Next, the load at failure in Newtons was divided by the cross-sectional area in square-millimeters (measured by a caliper) to report the microtensile bond strength in megapascals (*MPa*). The teeth were then inspected under a stereomicroscope (Olympus Co, Tokyo, Japan) at ×50 magnification to determine the mode of failure. The mode of failure was divided into four groups:

Adhesive: Failure at the tooth-adhesive interface or adhesive-composite interface

Cohesive failure in resin

Cohesive failure in tooth structure

Mixed failure

Normal distribution of data was evaluated using the Kolmogorov-Smirnov test. The bond strength of the five groups was compared using one-way ANOVA. A level of $p<0.05$ was considered as significant. The Fisher's exact test was used to compare the mode of failure of the groups. All the statistical analyses were carried out using SPSS version 22 (SPSS Inc., IL, USA).

Results

The Kolmogorov-Smirnov test confirmed normal distribution of data ($p>0.05$) in all five groups. Thus, the bond strength of the groups was compared using one-way ANOVA (Table 1). The maximum microtensile bond strength of composite to enamel was noted in group 2 while minimum microtensile bond strength was noted in group 3. The results exhibited that the five groups were not significantly different in terms of the mean microtensile bond strength ($p=0.110$).

Concerning the mode of failure, in groups 1 and 2, the majority of failures were cohesive while in the remaining three groups, most failures were of adhesive type (Table 2). Comparison of the mode of failure of the groups using Fisher's exact test revealed a significant difference ($p=0.01$).

Table 1. Mean bond strength (MPa) of the five groups (n=10)

Groups	Mean (MPa)	Std. deviation	Minimum	Maximum
Group 1	22.3620	6.59765	14.28	34.28
Group 2	25.9940	2.95996	21.33	29.62
Group 3	20.4850	4.91295	13.75	26.14
Group 4	25.9430	2.00891	22.04	28.57
Group 5	24.6650	7.99386	14.16	37.66

Table 2. Modes of failure in the five groups

Group	Mode of failure			
	Cohesive in enamel	Cohesive in composite	Adhesive	Mixed
Number	4	2	2	2
Percentage	40.0%	20.0%	20.0%	20.0%
Number	3	2	2	3
Percentage	30.0%	20.0%	20.0%	30.0%
Number	0	0	7	3
Percentage	0%	0%	70.0%	30.0%
Number	1	0	6	3
Percentage	10%	0%	60%	30%
Number	0	0	6	4
Percentage	0%	0%	60.0%	40.0%

Discussion

This study assessed the effect of internal bleaching on microtensile bond strength of composite to freshly veneered enamel. The results showed that bleaching treatment had no significant effect on microtensile bond strength of composite to enamel when performed immediately or one month after the veneering treatment. It is worth noting that most of the studies evaluated the effect of bleaching agents on bond strength of composite to the enamel which is veneered after bleaching. Majority of these studies have shown severe reduction in bond strength (14-17,18). Studies have reported a number of reasons to explain the reduction in bond strength of composite to the enamel following bleaching treatments such as the reduction in mineral contents of the enamel, increased porosity and reduction in enamel prisms (19-21). Lewinstein *et al* (22) reported that bleaching with 30% hydrogen peroxide decreased the microhardness of enamel and dentin following calcium loss and changes in their organic contents, which can be responsible for the reduction in bond strength to the enamel. Some other studies discussed that reactive oxygen species remaining in the tooth structure after bleaching are responsible for impaired bond strength of composite to the enamel and incomplete polymerization of bonding agent and composite (23-26). Türkkahraman *et al* (27) demonstrated that bleaching with 35% hydrogen peroxide caused some changes in the enamel, and the bond strength of orthodontic brackets to human enamel significantly decreased even after the use of anti-oxidative agents.

As known, clinicians may encounter situations in which the patients desire a rapid and satisfactory esthetic outcome. Routine procedures (*e.g.*, bleaching prior veneering) will definitely take more time and the demanded appearance will not be achieved immediately due to the delay which is required for optimum bonding. Barbosa *et al* (28) stated that the bond strength of composite to enamel significantly decreased after bleaching with 35% hydrogen peroxide bleaching agent; this reduction on days zero and seven after bleaching was significantly greater than that on day 14.

To preserve the time, the veneering procedure could be carried out as the first step and bleaching could be done afterwards. The only drawback is the probable hardly detectable mismatch between the final restorations and the adjacent teeth. This small discrepancy could be managed by altering the duration of bleaching process. Furthermore, a reliable bond strength could assure the longevity of restoration. Therefore, this study was conducted to investigate the effect of internal bleaching on microtensile bond strength of former veneer composite to tooth enamel.

As stated earlier, the current study found no significant difference in microtensile bond strength of the five groups. The difference between our findings and those of the abovementioned studies is due to the fact that bleaching was performed prior to the bonding of composite to the enamel. It means that the destructive effects of bleaching agents namely reduction in mineral content and hardness and decrease of bond due to the presence of reactive oxygen species in the tooth structure were eliminated. In addition, in this method, resin tag formation in the enamel and resin polymerization (which are imperative for bonding of composite to enamel) occur prior to bleaching. Therefore, no significant differences were observed between groups.

A number of studies have claimed that the longer the time interval between the bleaching procedure and provision of composite treatments, the smaller the adverse effects of peroxide on bond strength would be. They suggested postponing the composite restorations for 1 to 6 weeks after the bleaching procedure (8,28-31). However, controversy exists regarding the ideal time lapse between bleaching and composite restoration of teeth and this time period varies from 1 week 30 to longer periods of time (8,31). The bond strength was assessed 24 hours and one month after the bleaching procedure, however, in reverse order and the results exhibited no significant differences.

In the present study, the teeth were stored in artificial saliva to better simulate the clinical setting and also because evidence shows that immersion of teeth in distilled water, artificial saliva or saline results in restoring the bonding capability of the enamel (19,23,24,32-34).

In the current study, the microtensile bond strength test was utilized to measure the bond strength of composite to the enamel. This test is preferred to microshear test since it more evenly distributes the stress at the interface (35). The microtensile bond strength test is highly sensitive and has advantages such as enabling the measurement of regional bond strength and measurement of bond strength in irregular areas and tiny samples 36. In this study, the samples were prepared with 1 mm2 cross-sectional area, which seems to be an optimal size since Della Bona and Van Noort 36 showed that pre-test failures during the preparation of samples more commonly occur in samples with a cross-sectional area of 0.7 mm2 compared with those with a cross-sectional area of 1.4 (mm^2).

The bond strength should be assessed both quantitatively and qualitatively. Thus, the samples were evaluated under a stereomicroscope for qualitative assessment in our study. Determining the mode of failure along with mechanical parameters of failure is important in understanding and prediction of the reliability of the bonding interface and to decrease misinterpretations (37). Thus, the mode of failure of the samples was determined under a stereomicroscope at ×50 magnification in our study. Stereomicroscopic observations revealed that although bleaching had no significant effect on microtensile bond strength of composite to the enamel, failures in bleached groups were mainly adhesive while the mode of failure was mainly cohesive within the enamel or composite (with lower frequency) in non-bleached groups.

It is noteworthy that almost all the dental literature has been searched and no similar research was found. Unfortunately, this resulted in an incomprehensive discussion. Moreover, this study had an in vitro design, and thus generalization of the results to the clinical setting should be done with caution. Future clinical studies are required to assess the efficacy of conduction of bleaching after composite veneering of teeth in the oral environment.

Conclusion

Within the limitations of this in vitro study, the results showed that conduction of bleaching after composite veneering of teeth had no significant effect on bond strength of composite to the enamel. The mode of failure was mainly adhesive in bleached groups and cohesive within the enamel or composite (with lower frequency) in non-bleached groups.

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Conflict of Interest

None.

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