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Effect of Internal Bleaching on the Microshear Bond Strength of Composite Resin to Dentin in Recently Restored Teeth

Mohsen Rezaee[1], Azam Valian[1], Armita Tavakoli[2] and Mahsa Nikaein[3]*

1. Department of Restorative Dentistry, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
2. Private Practice
3. Department of Operative Dentistry, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

*** Corresponding author**
Mahsa Nikaein, MD
Department of Operative Dentistry, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran
Tel: +98 912 7146460
Email: msa_nik@yahoo.com

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Abstract

Background: This study aimed to assess the effect of internal bleaching on the microshear bond strength of composite resin to dentin in recently restored teeth.

Methods: This *in vitro*, experimental study evaluated 40 sound human premolars. The teeth were sectioned below their cementoenamel junction. Access cavity was prepared, pulpal tissue was removed and filled with glass ionomer. The teeth were then randomly divided into 4 groups. In the control group, no internal bleaching was performed and dentin surface was restored with composite. In group 2, internal bleaching with 35% hydrogen peroxide (Opalescence, ultradent) was performed 4 weeks after composite restoration. Bleaching was performed immediately after restoration of teeth in groups 3 and 4. Teeth were etched with 35% phosphoric acid for 15 seconds, rinsed, dried, and primer and adhesive (Adper Scotchbond Multipurpose) were applied. The teeth were then restored with Z250 (3M ESPE) microhybrid resin composite. Teeth were sectioned into 1 mm^2 sections and underwent micro-shear bond strength test. In groups 1 to 3, bond strength was measured after 24 hours while in group 4, it was measured after 1 month. Data were analyzed using one-way ANOVA.

Results: The mean micro-shear bond strength of composite to dentin was maximum in group 2 and minimum in group 3. However, the difference in this respect was not significant among the groups ($p>0.05$).

Conclusion: In teeth requiring immediate esthetic restorations, treatments can be performed after non-vital bleaching with no time restriction and adequately high bond strength comparable to non-bleached teeth.

Keywords: Composite dental resin, Dentin, Esthetics, Peroxides, Scotchbond

Introduction

The main focus of contemporary dentistry is to achieve esthetic results with minimally invasive procedures. Composite resins are increasingly used for esthetic restoration of teeth. They are suitable for correction of discolorations, rotated teeth, coronal fractures, diastema, discolored restorations, palatally positioned teeth, missing lateral incisors, abrasions and erosions (1).

Teeth may undergo discoloration due to a number of reasons. Extrinsic staining occurs as the result of stains and pigments present in foods and drinks as well as smoking while intrinsic discoloration may occur in non-vital teeth or due to medication intake. Non-vital discolored teeth (particularly due to endodontic treatment) commonly require esthetic dental treatments (2).

Tooth bleaching is a conservative approach for treatment of discolored teeth compared with composite veneers, porcelain restorations or crowns. Bleaching can be performed at home or in office (3). Hydrogen peroxide is commonly used for tooth bleaching, which breaks down and releases reactive oxygen species that target the colored molecules (4,5) and break them into smaller, less-colored molecules (4) Oxidizing agents commonly used in bleaching treatment include hydrogen peroxide with different concentrations, sodium perborate and carbamide peroxide. These chemical agents oxidize the organic stains and lighten the tooth color (6). At present, internal bleaching is a highly successful technique for correcting discolored non-vital teeth. However, the peroxide may remain in the tooth structure following the bleaching procedure and cause problems such as decreasing the bond strength of composite to bleached enamel and dentin and subsequent microleakage (7-10). Bleaching affects the morphology of dentin and enamel, destructs the enamel prisms and alters the organic and inorganic dentin contents (6,11) causing demineralization, damages cell DNA, denatures enamel proteins, cleaves the hydrogen bonds in the enamel and decreases the ratio of Ca/P in dentin (12-14).

Evidence have been shown that the longer the time lapse between internal bleaching and composite restoration, the smaller the adverse effects of hydrogen peroxide on bond strength would be (15). However, in some circumstances, patients require urgent esthetic dental treatments and a 2-week time lapse is not acceptable for them. In such cases, composite restoration of the tooth may be performed first followed by non-vital bleaching, given that non-vital bleaching has no adverse effects on the existing dentin-composite bond. Considering the gap of information on this topic, this study aimed to assess the effect of internal bleaching on microshear bond strength of composite resin into dentin in recently restored teeth.

Materials and Methods

This *in vitro*, experimental study evaluated 40 sound human premolars extracted for orthodontic treatment. The study was approved in the Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RIDS.REC.1346.614). Sample size was calculated to be 10 in each group (a total of 40) according to a previous study by Uysal *et al* (16) assuming type one error of 0.05, type two error (B) of 0.1 and study power of 90%.

The human premolars were sound and had no caries. All teeth were inspected under a stereomicroscope (C-DS, Nikon, Tokyo, Japan) at x50 magnification to eliminate the samples with cracks or hypoplastic lesions.

The pulp chamber was first opened. The organic debris was removed with a periodontal scaler. The teeth were washed with water and pumice paste. The teeth were then disinfected in 0.5% chloramine T solution (Merck, Germany) and stored in distilled water at 4°*C* for one week before the intervention according to ISO/TS 11405. Next, the teeth were 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 methylamino methane, with a pH of 7. The artificial saliva was refreshed daily.

For the purpose of standardization of surface properties and the smear layer, enamel was removed by a disc under water pressure. The buccal surfaces of the teeth were ground by 600-grit silicon carbide abrasive paper for 60 seconds under running water according to ISO/TS 11405. For internal bleaching, the teeth were sectioned at 2 *mm* below the cementoenamel junction. Access cavity was prepared, pulpal tissue was removed, glass ionomer was applied and the

Table 1. Mean dentin microshear bond strength of the four groups

Group	Mean	Std. deviation	Minimum	Maximum
Group 1 (control)	23.77	6.07	17.14	34.18
Group 2	20.58	4.45	13.56	25.93
Group 3	25.31	1.75	23.15	92.07
Group 4	22.43	7.38	15.32	35.55

teeth were randomly divided into four groups.

Group 1.

This group served as the control group. Bleaching was not performed. The dentin surface was restored with composite and the microshear bond strength was measured after 24 hours.

Group 2.

Internal bleaching was performed 4 weeks after composite restoration of teeth. The microshear bond strength was measured 24 hours after bleaching.

Group 3.

Internal bleaching was performed immediately after composite restoration. Microshear bond strength was measured 24 hours later.

Group 4.

Internal bleaching was performed immediately after composite restoration. Microshear bond strength was measured after one month.

All samples were etched with 35% phosphoric acid (Scotchbond Etchant; 3M ESPE, St. Paul, MN, USA) for 15 seconds. They were then completely rinsed and gently air-sprayed to remove excess moisture. Next, Adper Scotchbond Multipurpose primer and adhesive (3M ESPE, St. Paul, MN, USA) were applied in 2 layers and air-sprayed for solvent evaporation. Curing was performed for 10 seconds with a light intensity of 800 mW/cm^2 (Demetron, Kerr, CA, USA). Next, Z250 microhybrid composite (3M ESPE, St. Paul, MN, USA) was applied in 2 increments, each with 2 *mm* thickness and light-cured for 40 seconds.

For non-vital internal bleaching, 35% hydrogen peroxide (Opalescence, ultradent), was used three times with 3-5-day intervals.

The teeth were then immersed in artificial saliva at 37°*C* for 24 hours. They were then sectioned longitudinally into discs with 1 *mm* diameter using a Mecatome (Tzoia, France) such that samples had 1 mm^2 cross-sectional area. The samples were mounted in a universal testing machine (STM 20; Santam) and subjected to 500 N load applied at a crosshead speed of 1 *mm/min* until failure. The load at failure was then divided by the cross-sectional area measured by a digital caliper (Mitutoyo, Tokyo, Japan) with 0.01 *mm* accuracy to determine the shear bond strength in Megapascals (*MPa*).

Data were analyzed using SPSS 25 version (IBM Corp., Armonk, NY, USA). Normal distribution of data was evaluated using the Kolmogorov-Smirnov test, which revealed that the microshear bond strength data were normally distributed. Thus, parametric one-way ANOVA was used to compare the microshear bond strength of the groups. Level of significance was set at 0.050.

Results

Table 1 shows the mean dentinal microshear bond strength of the four groups. The mean microshear bond strength of composite to dentin was maximum in group 2 and minimum in group 3. According to one-way ANOVA, the mean microshear bond strength of the four groups was not significantly different ($p=0.27$).

Discussion

This study assessed the effect of internal bleaching on microshear bond strength of composite to dentin in recently restored teeth. The results demonstrated no significant difference in the mean microshear bond strength of the four groups.

Several studies have reported significant reduction in bond strength to enamel and dentin following internal bleaching treatments (17-19). However, it has been proved that different concentrations of carbamide peroxide have similar whitening efficiency (17). Lewinstein *et al* (20) represented that bleaching decreases the microhardness and subsequently the bond strength to enamel due to calcium loss and changes in organic contents of the enamel and dentin.

In some cases, reactive oxygen species generated in the process of bleaching remain in the tooth structure and impair the bond of composite to enamel and prevent complete polymerization of composite (21). Barbosa *et al* (22) demonstrated a significant reduction in bond strength of composite to bleached enamel and reported that this reduction on days 0 and 7 after bleaching was significantly higher than that on day 14.

Barcellos *et al* (23) evaluated the effect of application of high concentrations of carbamide peroxide on the bond strength of dental substrate to composite resin and reported a negative correlation between the concentration of carbamide peroxide and the mean bond strength values to enamel and dentin. Lago *et al* (24) reported a significant reduction in bond strength of restoration immediately after bleaching with 35% hydrogen peroxide and. They did not find any significant difference in bond strength of teeth restored at 7 and 14 days after bleaching and the control group, which highlighted the effect of time on the bond strength. Shinohara *et al* (25) measured the microshear bond strength of composite to enamel and dentin at different time points after non-vital bleaching and reported a significant reduction in bond strength of composite to enamel and dentin at 1 day after bleaching. The reduction in shear bond strength was time-dependent. Türkün and Türkün (26) reported that non-vital bleaching with 10% carbamide peroxide had adverse effects on immediate seal of composite restorations. Shinohara *et al* (27) evaluated non-vital bleaching on microshear bond strength of composite and reported that non-vital bleaching with sodium perborate may have adverse effects on the shear bond strength of composite resin to enamel and dentin. This finding was different from our results due to the reverse order of procedures in our study.

During the process of tooth bleaching, hydrogen peroxide diffuses into the organic matrix of enamel and dentin. Due to low molecular weight, hydrogen peroxide easily penetrates deep and reacts with organic coloring agents in tooth structure, causing oxidation and reduction of colored molecules (28). Residual oxygen after the bleaching process can prevent complete penetration of resin into the dentin structure (29).

Phosphoric acid etching of bleached dental surfaces (with low mineral content) causes their over-etching (30). Deep demineralization caused by phosphoric acid along with the reduction in mineral content of dentin after bleaching and shallow penetration of resin into the tooth structure due to the presence of residual oxygen may explain lower bond strength to bleached enamel. Changes due to reduction in mineral content, increased porosity and decreased number of enamel prisms can attenuate the bonding surfaces (31,32). Penetration of hydrogen peroxide into the enamel, formation of free radicals and subsequent inhibition of polymerization and formation of resin tags are among the main reasons behind the reduction in bond strength of composite to bleached enamel (33). Peroxide ions can replace free radicals in the hydroxyapatite network and form peroxide apatite, causing destruction of the structure of enamel prisms and decreasing the bond strength (34).

In the majority of studies related to this topic, bleaching treatment was performed prior to bonding of composite to dental substrate and all of them indicated the negative effects of bleaching on bond strength. In the present study, composite veneering of the teeth was performed first and then non-vital bleaching was performed with no time restriction. Since formation of resin tags and their polymerization within the enamel occur before the bleaching treatment in this strategy, no significant reduction in bond strength of composite to bleached teeth was observed.

Ferrari *et al* (35) evaluated the effects of internal bleaching on shear bond strength of composite-composite used for core build-up and reported that internal bleaching products had no adverse effect on the bond strength at the composite-composite interface. Their observations were in agreement with our findings. Also, Arcari *et al* (36) evaluated the microtensile bond strength of nanofilled composite resins to human dentin after non-vital bleaching and showed no significant differences in bond strength between different bleaching agents at different time points after bleaching.

Kilinc *et al* suggests that internally bleached enamel should be restored only after delayed 14 days or after a week if ascorbate antioxidant treatment is applied (37).

Several methods have been proposed to increase the bond strength after bleaching treatments.

Curylofo *et al* used Er:YAG treatment on dentin for immediate restoration after bleaching with 38% hydrogen peroxide and found that laser irradiation can restore immediate dentin-restoration bond strength (38). The most commonly practiced strategy is to postpone the restoration (any bonding procedure) for approximately 2 weeks after the bleaching treatment (39).

In the present study, the microshear bond strength of composite to bleached dentin was comparable to that of control group. Also, the time interval between the restoration of teeth after the bleaching procedure and the bleaching treatment cause no significant difference among the groups. It seems that immersion of teeth in artificial saliva results in release of oxygen from the bleached tissue and yields a bond strength comparable to that of non-bleached tooth (15).

It should be noted that this study had an *in vitro* design and complete simulation of clinical setting is not feasible *in vitro*.

Conclusion

In teeth requiring immediate esthetic restorations, treatments can be performed before non-vital bleaching with no time restriction and adequately high bond strength comparable to non-bleached teeth. Further studies on other types of bonding agents, composite resins and bleaching agents are required to assess the effect of bleaching after composite restoration on the bond strength. Also, microleakage of composite restorations following bleaching treatment can be evaluated in future studies.

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