

Effect of Repeated Bleaching Procedures on Surface Color and Shear Bond Strength of Resin Composite Bonded Enamel

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Abstract: Statement of the Problem: When repeated clinical applications of bleaching procedures are needed and presence of adhesive restorations it is generally some restoration surface changes are occurred but what is recommended with in office repeated bleaching procedures. Also the effect on shear bond strength of resin composite bonded to enamel. **Purpose:** The purpose of this in vitro study was to determine the effect of in office repeated bleaching procedures on restoration surface color and the shear bond strength of restoration to enamel. **Methods:** A gel consisting of 30% carbamide peroxide was applied to ground buccal surfaces of resin composite bonded to enamel surfaces of premolar teeth. The color changes of resin composite surfaces are detected using Environmental Scanning Electronic Microscope. The shear bond strength of the restorative systems to enamel was tested, and data was evaluated using two-way analysis of variance and Tukey HSD tests. **Results:** Significant differences ($p < 0.05$) in shear bond strengths were found among repeated bleaching procedures. **Conclusion:** repeated vital tooth bleaching with carbamide peroxide gel has an adverse effect on enamel shear bond strength to existent P60 resin composite.

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Key words: repeated enamel bleaching, adhesive restoration, enamel shear bond strength

1. Introduction

In the last decade, Tooth discoloration is becoming a greater concern as more emphasis is placed on esthetics. With the growing awareness of esthetic options, there is a greater demand for solutions to such unsightly problems as food staining, fluorosis, and tetracycline staining. Bleaching systems have been received by the public as a more conservative and economical method of improving the appearance of teeth. Currently, several bleaching systems are available in the dental market to be used for improving tooth color which include in-office bleaching⁽¹⁻³⁾, home bleaching, and over-the counter bleaching products.

Chemical softening resulting from bleaching was considered as a potential impact on the physical-mechanical properties of some tooth colored materials, such as microhardness and roughness⁽⁴⁻⁷⁾. However, an important esthetic property of these materials, color, has not attracted much attention. A limited number of studies have reported the color change of tooth-colored materials due to bleaching treatments. These studies used varied concentrations of bleaching products, durations of exposure, and testing materials. Prior studies have reported that the color changes of composites resulting from 10% carbamide peroxide (CP) were similar to those of the composites stored in water and were undetectable to

the human eye^(8,9). However, a significant color improvement following bleaching using 10% CP has been illuminated by other researchs.^(10,11) Shinohara *et al*⁽¹²⁾ found that in class-V restorations, the increase of microleakage after intra-coronal application of 37% carbamide peroxide was only detected in dentin margins and not in enamel margins. While a study by Ulukapi *et al.*,⁽¹³⁾ Detected that microleakage rates of labial restorations with enamel margins only, were significantly increased after 10% carbamide peroxide bleaching.

2. Material and Methods

I- Preparation of the Samples

A total of 60 caries-free permanent premolars, which were extracted for orthodontic reasons, were used in this study. Individual tooth surfaces were hand scaled to remove any remaining soft tissue. All teeth were stored in distilled water at -20°C. Crowns were separated from the roots 2 to 3 mm apical to the cemento-enamel junction using a diamond saw (Isomet, Buehler, Lake Bluff, IL, USA) under water irrigation at a low speed. With their labial surfaces exposed, the crowns were then embedded in self-curing acrylic resin (Meliodent, Heraeus Kulzer, Dormagen, Germany) into Teflon molds. Specimens were wet ground using 300- and 600-grit silicon carbide paper, for 30 s / paper, to achieve evenly flat

enamel surfaces, and then cleaned in distilled water to remove any remaining silicon carbide particles. All enamel surfaces were examined under a stereomicroscope (Leica, MZ 12, Leica AG, CH-9435 Heerbrugg, Switzerland), and any specimens with cracks or hypoplastic defects were excluded.

II- Sample classification:

The total 60 Specimens were randomly divided into three groups.

Group I : 20 specimens are tested without any bleaching treatment.

Group II : 20 specimens are tested with repeated bleaching treatment for 2 times.

Group III : 20 specimens are tested with repeated bleaching treatment for 6 times.

III- Application of Bonding Agents and Preparation of Resin Composite specimens:

Enamel surfaces were cleaned with water spray for 5 seconds and dried with oil and water-free compressed air for 3 seconds. Details of bonding adhesives and composites are provided in Tables 1. Before the applications, an adhesive tape with a central orifice of 3 mm in diameter was applied to the enamel surfaces to demarcate the area to be treated.

Bonding agents were then cured using a quartz tungsten- halogen (QTH) light curing unit (Hilux Ultra Plus, Benlioglu Dental, Istanbul, Turkey) in standard mode. The light intensity of the unit was monitored with a radiometer (Curing Radiometer, Model 100, Demetron/Kerr Corp., Danbury, CT, USA) throughout the experiment and did not drop below 550 mW/cm². Selection of a specific shade of tested resin composite A2 Resin composite materials were applied to the prepared enamel surfaces perpendicularly by attaching a Teflon tube (3 mm wide and 2 mm high) to the prepared enamel surfaces. Composite materials were light-cured 40 seconds from each perpendicular direction using the same QTH light curing unit. Last composite layer was covered by Mylar strips. Following curing, the Teflon tube was carefully removed, the composite specimens was checked, and any specimens with visible air bubbles or gaps at the interface were discarded.

IV- Bleaching Procedures:

Experimental groups, tested after bleaching, were subjected to a bleaching regimen with a 30% carbamide peroxide bleaching system (VivaStyle 30%, Ivoclar Vivadent, USA) of 1 application per week at 20 – 30 minutes /application. This regimen is consistent with the recommendations provided by the manufacturers of many of the 30% carbamide peroxide bleaching systems available on the market. Bleach was applied using custom trays fabricated for each tooth specimen. All specimens were stored in distilled water at 37 °C except during bleaching.

V- Shear Bond Strength Testing:

The shear bond strength of resin bonding systems was tested according to International Organization for Standardization (ISO) procedures (ISO/TS 11405)⁽¹⁴⁾. Prepared specimens were stored in distilled water at 37°C for 24 hours prior to shear bond strength testing, and specimens were debonded using a universal testing machine (Lloyd LRX Universal, Lloyd Instruments, Fareham, Hants, England, UK) at a crosshead speed of 1.0 mm/minute at room temperature (23± 2°C).

Specimens were secured in a mounting jig (Bencor Multi-T shear assembly, Danville Engineering Inc., San Ramon, CA, USA) with the shearing rod against and parallel to the flat prepared bonding sites. The distance from the probe to the enamel surface was monitored using a spacer of two celluloid matrices. Shear bond strengths were calculated by dividing the highest fracture force (N) by the bonded area (3 mm diameter) and recorded in megapascals (MPa). Debonded specimens were examined under a stereomicroscope (Leica, MZ 12) at 25 × magnification, and failure modes were recorded based on the percentage of substrate-free material as either adhesive failure, cohesive failure in composite/adhesive resin with partial adhesive failure (mixed mode), or cohesive failure in enamel⁽¹⁵⁾.

VI- Color Measurement:

The tested composite surfaces were examined under Environmental Scanning Electronic Microscope (ESEM). The device (ESEM) has the ability to capture an image for the analyzed sample with magnification up to 1000000 X. The analyzed sample is placed at the analyzing chamber in the ESEM, and then by using the ESEM we specify the certain area that can be captured at a certain magnification. After capturing the image of the specified area, an order is given to the measurements software (XT document) to begin to make its measurements up on the specified sample. These measurements are taken according to specified points pointed by the user of the device. After making the measurements in pixel unit, these measurements are represented in an excel sheet called (data sheet). The same software works upon the data sheet and get from it more statistical data. These statistical data are (counts: number of the measured points, Mean: the mean of the measured points values, Maximum: maximum measured bright point value, Minimum: minimum measured bright point value). The mean data help us in comparing the different samples or applications.

VII-Topographic evaluation:

The Scanning Electron Microscopic (SEM) examination was carried out using QUANTA 200 scanning electron microscope attached with EDX

unit, with accelerating voltage 30 K.V., magnification 10x up to 400.00x. Selected samples were rinsed in distilled water and cleaned with a gauze wetted with 98% ethanol alcohol and then dried in an oven at 75 °C for 15 min. The specimens

were mounted on a metallic holder of one cm² in diameter & two mm in height, using a carbon adhesive paste. Then the samples were examined with SEM* and photographed.

Table (1): Tested materials

Material, manufacturer	Main components	Lot no.	Application
Scotchbond Etchant gel, 3M ESPE, St. Paul, MN, USA	Phosphoric acid 35%	N 110268	Etchant was applied onto enamel surface for 15 seconds and rinsed for 10 seconds.
Adper single bond 2, 3M ESPE, St. Paul, MN, USA	10%, 5nm colloidal filler, 2hydroxyethylmethacrylate	N 111663	Two consecutive coats of bond were applied to etched enamel for 15 seconds with gentle agitation and gently air thinned for 5 seconds to evaporate solvents. Bond was light-cured for 10 seconds.
Filtek P60, 3M ESPE, St. Paul, MN, USA, Microhybrid	Resin matrix: Bis-GMA, UDMA, Bis-EMA Filler: zirconia/silica 0.01–3.5 mm. 60 vol%	N 114410	
VivaStyle 30%, Ivoclar vivadent, USA		4114-8-A	20-30 minute /application

Results:

Statistical Analysis

Data were presented as mean and standard deviation (SD) values. One-way Analysis of Variance (ANOVA) was used for comparisons between the three bleaching methods. Tukey's post-hoc test was used for pair-wise comparison between the groups when ANOVA test is significant.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM (IBM Corporation, NY, USA.) SPSS (SPSS, Inc., an IBM Company.) Statistics Version 20 for Windows.

Shear bond strength results:

The mean and standard deviation values of shear bond strength were 29.1 ± 1.1 MPa, 23.7 ± 0.4 MPa, and 22 ± 0.5 MPa for Groups 1, 2 and 3, respectively.

Group 1 showed the statistically significantly highest mean micro-shear bond strength. There was no statistically significant difference between Group 2 and Group 3; both showed the statistically significantly lowest mean shear bond strength.

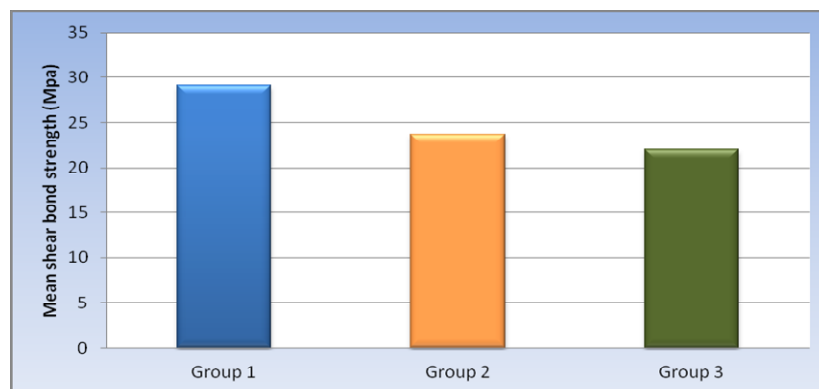


Figure (1): Bar chart representing mean shear bond strength of the three groups

Color changes results:

The mean and standard deviation values of color values were 130.5 ± 1.4 Pixels, 152.1 ± 1.2 Pixels, and 287.4 ± 3.5 Pixels for Groups 1, 2 and 3, respectively.

Group 3 showed the statistically significantly highest mean color value. This was followed by Group 2. Group 3 showed the statistically significantly lowest mean color value.

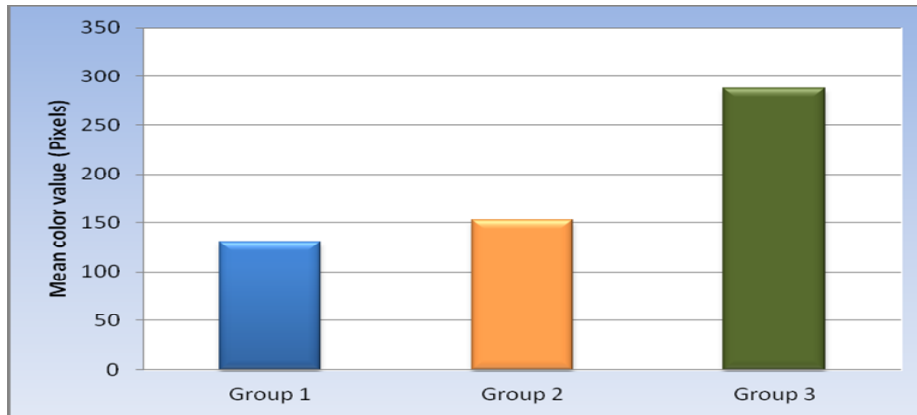
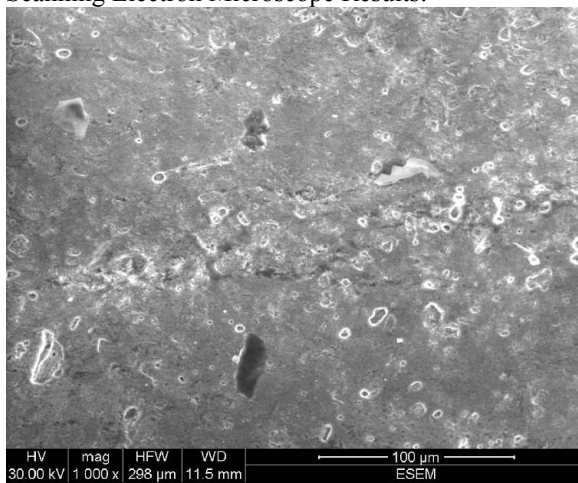
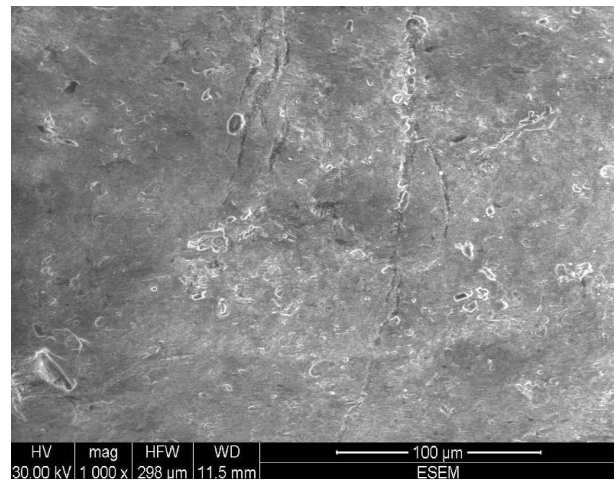


Figure (2): Bar chart representing mean color values of the three groups

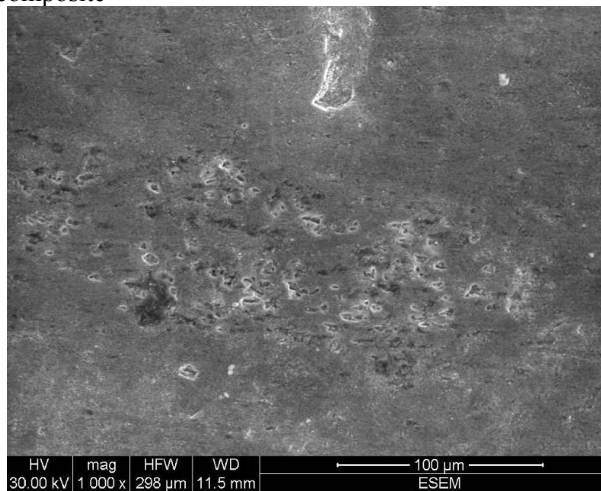
Scanning Electron Microscope Results:



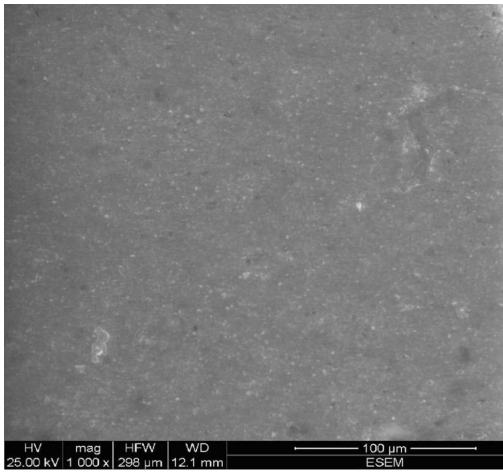
Photomicrograph(1):Scanning electron micrograph showing debonded resin composite restoration from enamel without bleaching procedures. Also show adhesive /cohesive failure in composite



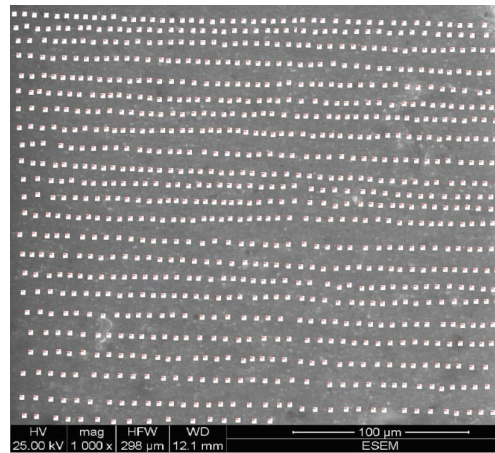
Photomicrograph(2):Scanning electron micrograph showing debonded resin composite restoration from enamel with repeated two time bleaching procedures. Also show adhesive failure.



Photomicrograph(3):Scanning electron micrograph showing debonded resin composite restoration from enamel with repeated six time bleaching procedures. Also show adhesive failure.

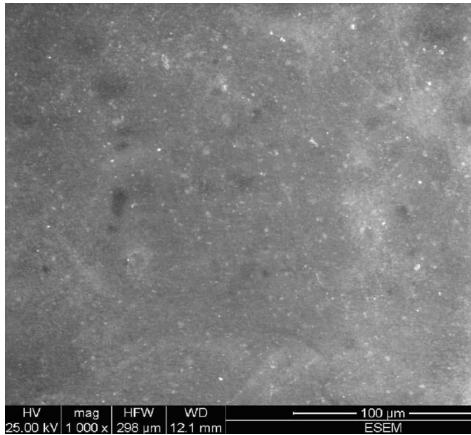


A

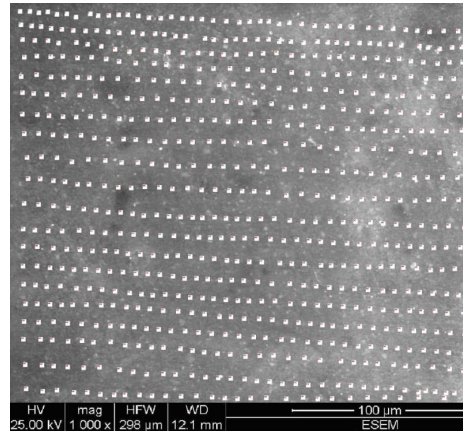


B

Photomicrograph(4):Scanning electron micrograph showing A : Resin Composite surface without any bleaching procedures B:the color measurement of unbleached composite surface

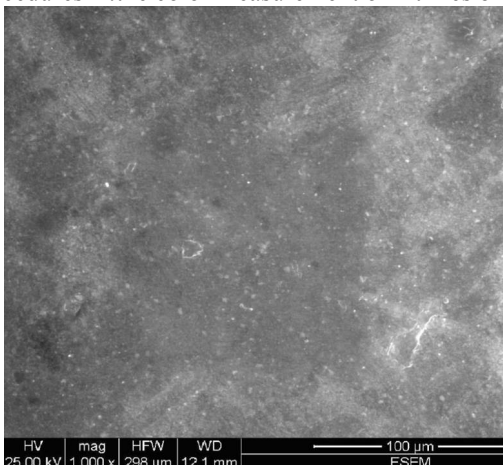


A

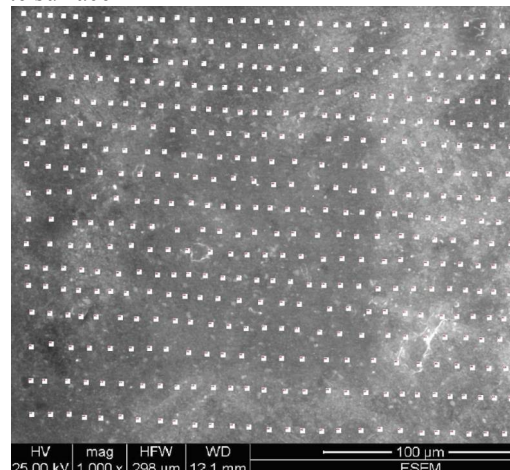


B

Photomicrograph(5):Scanning electron micrograph showing A : Resin Composite surface with 2 times bleaching procedures B:the color measurement of 2 times bleached composite surface



A



B

Photomicrograph(6): Scanning electron micrograph showing A: Resin Composite surface with 6 times bleaching procedures B:the color measurement of 6 times bleached composite surface

4. Discussion:

In our study, according to enamel shear bond, Group 1 showed the statistically significantly highest mean shear bond strength. Also there was no statistically significant difference between Group 2 and Group 3; both showed the statistically significantly lowest mean shear bond strength, and this is in acceptance with Al-Salehi *et al.*⁽¹⁶⁾ who showed that bleaching agents can cause the loss of calcium and phosphorus from dental structure. Thus, microstructural changes occur in enamel^(17,18) up to a depth of 50 μm ⁽¹⁹⁾. It is possible that these structural changes may cause degradation at the adhesive interface of pre-existing restorations. In addition, when in contact with resin composite, bleaching agents may cause an increase in surface roughness and porosity^(7,20) in addition to surface changes⁽²¹⁾. According to Sarrett *et al.*⁽²²⁾, these changes occur because the organic matrix makes the resin more susceptible to chemical reactions. Although adhesive systems have a higher amount of matrix than resin composites, these changes would be greater and the interfaces more susceptible to adhesive failure. Crim⁽¹⁾ and Ulukapi *et al.*⁽¹³⁾ found that bleaching agents (10% or 16% carbamide peroxide) caused adverse effects to the tooth/restoration Interface.

In this study, according to resin composite surface color, Group 3 showed the statistically significantly highest mean color value. This was followed by Group 2. Group 3 showed the statistically significantly lowest mean color value.

These results indicated that the 30% CP bleaching agent significantly influenced the color of the tested composite material.

The SEM figures showed that the bleaching treatment led to surface dissolution in the materials. Tiny pores on the surface, resulting from the matrix dissolution, occupied by air or saliva. The differences of optical properties among the materials, air, and water increased the reflectance on the surface⁽²³⁻²⁵⁾.

The color stability of a resin composite is related to the resin matrix, dimensions of filler particles, depth of polymerization and coloring agents^(26,27). Satou *et al.*⁽²⁸⁾ elucidated that the chemical differences amongst resin components such as purity of the oligomers and monomers, concentration or type of activators, initiators and inhibitors, oxidation of unreacted carbon-carbon double bonds may also affect the color stability. Microcracks and microvoids located at the interface between the filler and the matrix are the most likely penetration pathways for stain. The roughness of the surface caused by wear and chemical degradation may also affect gloss and consequently increase the extrinsic staining.^(29,30)

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