THE EFFECT OF COMBINED BLEACHING AND MICRO-ABRASION THERAPIES ON THE INTERFACIAL MICRO-MORPHOLOGY AND SHEAR BOND STRENGTH OF TWO DENTAL ADHESIVES TO HUMAN ENAMEL

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ABSTRACT

In complex cases of enamel fluorosis or enamel dys-mineralization, combined bleaching and micro-abrasion therapies may be advocated. The aim of the present study was to investigate the effect of combined in-office bleaching and micro-abrasion on the bond strength of two dental adhesives bonded to surface enamel. The interfacial micro-morphology of the involved surfaces was also studied by using SEM. Materials and methods: A total of 26 extracted human premolars were used to prepare 52 samples exposing enamel surfaces. Samples were randomly assigned to two groups to test the bonding with two dental adhesives. Each group was further subdivided into 2 subgroups of 10 each according to the treatment sequence. Three samples from each subgroup were processed for SEM to study the interfacial micro-morphology. Samples were subjected to shear bond strength testing. Results: statistical analysis revealed that Rely-a light bond exhibited significantly higher shear bond strength when enamel was bleached then micro-abraded. However, when using Exite bond, the sequence of the treatment reported an insignificant difference. Conclusions: (1) The sequence of the treatment has an effect on the shear bond strength depending on the type of the adhesive used. (2) When combined bleaching and micro-abrasion therapy is considered before bonding with fluoride releasing bond, it could be advantageous to begin with bleaching procedures, while bonding with adhesives containing organic solvents is not affected by the sequence of the treatment. (3) Fluoride releasing adhesive systems together with subsequent micro-abrasion could reduce or eliminate the adverse effects of bleaching systems so they are recommended for immediate bonding of orthodontic brackets or esthetic composite veneers. (4) The micromorphological features at the tooth-restoration interface varied with the different surface treatments used.

INTRODUCTION

There is an ever growing demand for esthetic dental treatment. Some intrinsic enamel defects, such as opacities, spots, streaks and brown pigmention resulting from fluorosis or tetracycline ingestion can adversely affect the color and translucency of enamel and hence the beauty of the smile. Treatment modalities include bleaching, micro-abrasion, ceramic or composite veneers as well as crowns. Vital tooth bleaching is a safe and well accepted procedure for treatment of surface and intrinsic staining of teeth. Since then, various whitening
systems have been developed and peroxide components at different concentrations are currently being used to bleach enamel (Cavalli et al; 2004). In-office vital bleaching comprises the use of peroxides in concentrations higher than those used for at-home bleaching. The bleaching agent gradually interacts with stains located within the superficial layers of tooth structure and thus produces the lightening effect (Haywood and Heymann; 1991).

Bleaching could not only lighten superficial brown stains but also can lighten the overall shade of the stains rendering them unrecognizable. Any remaining white or brown discoloration could be eliminated using micro-abrasion. Such a combined therapy may provide minimally invasive treatment of the esthetic defects which can yield ideal long lasting improvement. (Cvitko et al; 1992, Croll; 1992, Vanessa et al; 2007, Ardu et al; 2008)

Enamel micro-abrasion technique may be indicated in certain clinical scenarios to remove superficial stains by simultaneously eroding and abrading discolored enamel surfaces, namely abrosion effect, with an abrasive / acid compound with a paste of 18 % hydrochloric acid and flour of pumice (Lynch et al;2003). A commercial product based on this technique, PREMA compound (premier Dental products), was introduced in 1989 (Civitko et al; 1992). The compound includes silicon carbide abrasive particles and a mild concentration of hydrochloric acid in a water soluble siliceous gel-paste, when applied by a special mandrel on a gear-reduction hand piece, an insignificant and unrecognizable amount of enamel is removed (Croll; 1990 and 1993). However, enamel micro-abrasion followed by dental bleaching may be indicated for patients after orthodontic treatment and hence the treatment order could be reversed (Killian; 1993 and Croll; 1992 & Croll and Segura; 1996). Should the stains prove too deep for elimination, a bonded photopolymerizable resin composite restoration could be considered (Croll; 1989, 1990, and 1996). Tooth bleaching agents may adversely affect the tooth structure Surface defects; roughness, demineralization, and degradation of sound enamel were reported by SEM studies (Ernst et al; 1996, Worschech et al; 2003, Hosoya et al; 2003 and Cavalli et al; 2004). Moreover, it was reported that enamel microhardness was decreased significantly and ion release from both enamel and dentin increased with increasing hydrogen concentration (Shannon et al; 1993, McCracken and Haywood; 1995, Uysal et al; 2003, Al-Salehi et al; 2007).

These adverse effects of peroxides together with micro-abrasion are of clinical concern in cosmetic dentistry and orthodontics especially when bonding resin composite, porcelain veneer restorations or orthodontic brackets to enamel surfaces compromised with the combination therapy is to be considered.

The aim of the present study was to investigate the effect of combined in-office bleaching and micro-abrasion therapy on the shear bond strength of two different dental adhesives bonded on surface enamel under in-vitro experimental conditions. The interfacial micro-morphology of the involved enamel surfaces was also studied by using SEM.

**MATERIALS AND METHODS**

**Specimen preparation**

A total of 26 freshly extracted human premolars, extracted for orthodontic reasons were included in this study. Teeth were cleaned with a brush and stored in saline solution in the refrigerator. Roots were sacrificed and crowns were sectioned with a diamond disk into buccal and lingual halves to prepare a total of 52 specimens. Enamel presenting cracks or stains was discarded.

Crowns were embedded individually in a self-curing polystyrene resin using a mold of 2-cm width, 2-cm length, and 1-cm height allowing the external surface of enamel to be exposed. Enamel was leveled with a water cooling mechanical grinder in order to shape a plain enamel surface for testing. Discs were used in a sequential granulation of 400, 600, 1000 grade sandpaper. Thereafter, enamel was polished with rubber wheels.
Fifty two specimens were randomly assigned into four groups of thirteen each.

Experimental groups and variables are listed in table (1). Three samples from each group were processed for SEM to study the interfacial micro-morphology.

Forty specimens were randomly assigned into four groups of ten each.

**Bond I: Excite**

Total etch adhesive system. It consists of total etch of 37% by weight phosphoric acid, silicon dioxide and pigments and a filled light curing single component bonding agent for enamel and dentin.

Excite contains hydroxyl ethyl methacrylate (HEMA), dimethacrylate, phosphoric acid acrylate, highly dispersed silicon dioxide, initiators and stabilizers in an alcohol solution. (Ivoclar, Vivadent, F 29207)

**Bond II: Rely-a Light Bond**

It consists of: - Total etch adhesive system using 37% by weight phosphoric acid.
- Fluoride releasing light cure sealant resin.
- Light bond fluoride releasing light cure adhesive paste.

(Reliance-Itasca IL- USA, 1-800-323-4348)

**Bleaching procedures**

Lumawhite™ bleaching system (USA part = 210033) was used in this study. It consists of catalyst powder, 35% hydrogen peroxide and mixing stick. A Light Emitting Diode LED- technology (2810 via orange Way, Spring Valley, CA 91978- USA) was used to produce a high speed, safe and cool in-office power whitening system.

**TABLE (1) Experimental groups and variables**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Enamel Surface Treatment</th>
<th>Adhesive system</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Bleaching + Micro-abrasion</td>
<td>Bond I ( Exite)</td>
</tr>
<tr>
<td>(2)</td>
<td>Micro-abrasion + Bleaching</td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td>Bleaching + Micro-abrasion</td>
<td>Bond II ( Rely a bond)</td>
</tr>
<tr>
<td>(4)</td>
<td>Micro-abrasion + Bleaching</td>
<td></td>
</tr>
</tbody>
</table>

Fig (1) Lumawhite™ bleaching system. A-bleaching kit. B-catalyst powder and Hydrogen peroxide ampoule. C- Luma-cool light emitting diode.
It is a wavelength specific and high intensity light delivery system.

Luma-white™ bleach was prepared by removing the top of the catalyst powder jar. One 35% hydrogen peroxide pre-measured ampoules was opened by cutting off the top. The flattened tip was pointed to the powder jar and the contents were dispensed entirely onto the catalyst powder.

The powder and liquid were mixed slowly using the provided brush for at least 10 seconds. The mix was applied to the tested sample area using a brush to a consistent covering of 2 mm – 3 mm thick. The Full smile illuminator was positioned as close as possible to the surface of the samples. Six samples were exposed at a time. The digital timer was adjusted to 8 minutes and the samples were exposed three times. When the cycle was completed, the bleaching paste was removed by using high suction tip. Samples were then wiped with gauze pad to remove any remaining bleach residue. A fresh mix was prepared each time. Samples were then rinsed with water and dried with a piece of gauze.

**Bonding procedures**

Following the combined therapy, specimens were then washed and dried. The demarcated area was etched with phosphoric acid for 30 seconds, rinsed with air / water syringe for 15 seconds and dried with compressed air for 5- seconds. Adhesive bond was applied according to the manufacturer instructions for each bonding system. A split Teflon mold with a circular hole of 3mm in diameter and 0.5 mm height was placed on the tested area. Two increments of Tetric Ceram or light fluoride releasing resin composite were packed into the mold and orthodontic buttons were attached to the composite material. Each increment received 40 seconds light curing. After curing, the split mold was removed and the specimens were stored in 100% relative humidity at 37°C for 48 hours prior to testing.

**Shear Bond Strength Testing**

A special attachment with circular hole of 3 mm diameter was fabricated to be used in the Lyloid testing machine. The shear bond strengths were calculated and expressed in Mpa.

**SEM examination**

Samples were prepared such that the interfacial structure between enamel and resin could be observed. Specimens were then gold sputter coated and examined under SEM.

**RESULTS**

Statistical analysis of this study was carried out using (SPSS - Release 12) for Windows. Analysis of Variance (ANOVA) test followed by Student-Newman-Keuls (S-N-K) test was used to compare between the mean shear bond strengths of the four groups. Student’s t-test was used to study the effect of bond type, bleaching and/or micro-abrasion on mean shear bond strength. Statistical significance is achieved when the (P-value ≤ 0.05).

**Comparison between mean shear bond strengths of the four groups**

ANOVA test was used to compare between the mean shear bond strength (MPa) of the four groups. Student-Newman-Keuls test was used when ANOVA test renders a significant result in order to determine the statistically significant means. The mean, standard deviation (SD) values and results of ANOVA and (S-N-K) tests are presented in Table (2) and Fig. (2):
There was a statistically significant difference ($P < 0.05$) between the mean shear bond strengths of the four groups. S-N-K test results showed that there was no statistically significant difference between groups (I, II and IV) while group III showed significantly higher mean shear bond strength.

**Effect of bleaching and micro-abrasion sequence on mean shear bond strengths**

Student’s t-test was used to compare between the mean shear bond strength (MPa) using either (micro-abrasion then bleaching) and (bleaching then micro-abrasion). The means, standard deviation (SD) values and results of Student’s t-test are presented in the following tables and graphs:

**A. TABLE (3): Using Exite bond**

<table>
<thead>
<tr>
<th>Bleaching + Microabrasion + Ex</th>
<th>microabrasion + Bleaching + Ex</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN ($n = 10$)</td>
<td>SD</td>
<td>MEAN ($n = 10$)</td>
<td>SD</td>
</tr>
<tr>
<td>13.09</td>
<td>3.79</td>
<td>12.69</td>
<td>3.51</td>
</tr>
</tbody>
</table>

$n$: number of specimens, SD: Standard Deviation, *: Significant at $P \leq 0.05$

There was no statistically significant difference ($P > 0.05$) between the mean shear bond strengths of the two groups.
There was a statistically significant difference (P < 0.05) between the mean shear bond strengths of the two groups. (Bleaching then micro-abrasion) showed statistically significantly higher mean shear bond strength than (Micro-abrasion then bleaching).

### Results of SEM

**Fig (4) Mean shear bond strength of (Rely-a Light)**

**Fig (5) Represents resin-enamel interface of bleached then micro-abraded enamel and bonded using Exite adhesive. E: enamel, R: resin composite. Note the presence of micro-gaps (arrows) alternating with areas of resin tags**

**Fig (6) Represents resin-enamel interface. Enamel was bleached then micro-abraded and bonded using Rely-a light bond. E: enamel, R: resin. Few micro-gaps were detected.**

**Fig (7) Represents resin-enamel interface of micro-abraded then bleached enamel and bonded using Exite adhesive. E: enamel, R: resin composite. Note the presence of deep micro-gaps (arrows).**
Conservative techniques for improving the appearance of discolored teeth have become popular in the past decade. Combining enamel micro-abrasion with dental bleaching has emerged as the best way to treat certain fluorosis and fluorosis – type enamel dysmineralization defects (Cvitko et al.; 1992, McEvoy; 1995, Croll; 1993, and 1996 and Croll and Segura; 1996). Recent innovations for in-office bleaching include chair-side mixing gels, some of which are activated by curing lights. It was reported that light augments tooth whitening effect with peroxide to a greater extent than did peroxide or light alone (Tavares et al; 2003). Lumawhite whitening system uses light emitting diode that does not produce light by heating of a metal filament but by a quantum mechanical effect. This converts electricity to light with minimal heat generation.

Hydrogen peroxide and hydrochloric acid are two chemicals that have been recommended for use alone and in combination with other agents for removal of a variety of intrinsic stains from vital teeth. In complex cases of tooth discoloration where enamel stains penetrate deeply into the tooth tissue, a bonded resin composite or porcelain veneer restorations are the best treatment options.

In this study, enamel surface was ground and pumiced to remove the organic rich layer and hence to create a uniform surface for comparison of etching effects (Ruse et al; 1999, Lai et al; 2002).

Several studies have been conducted to evaluate the interaction between bleaching treatments and the bonding capacity of dental substrates. The results, although sometimes divergent possibly for methodological point, to a decrease in the bond strength of dental tissues submitted to bleaching, meaning that the presence of residual oxygen could interfere with resin attachment and inhibit resin polymerization (Kaya and Turkun; 2003). Having low molecular weight, hydrogen peroxide can penetrate enamel even to reach the pulp (Gokay et al; 2000). Consequently, peroxides may be absorbed/adsorbed by enamel despite of brief periods of washing and drying (Adibfar et al; 1992, Hanks et al; 1994 and Wataha et al; 1994). Moreover, continuous leaching of hydrogen peroxide will result in its retention in the bleached enamel. Thus the inner oxidative effects are more likely to occur in the subsurface enamel where more organic material is present and oxidation is capable of altering the outer enamel and the surface (Hegedus et al; 1999). Since dental adhesives polymerize by a free radical polymerization mechanism that involves the generation of free radicals through light activated redox initiator, the hydrogen peroxide may breakdown to release oxygen that is trapped within the adhesive during light activation. This suggests that there might be some kind of polymerization inhibition taking place. This effect was reported to be more evident in-vitro but not seen in-vivo (Dishman et al; 1994 and Justino et al; 2004).

Results of this study revealed that bonding with Exite adhesive to enamel pretreated with combined bleaching then micro-abrasion did not produce any significant difference when the treatment sequence was reversed i.e. micro-abrasion then bleaching, both recorded shear bond strength of 13.09 and 12.69 MPa respectively. Scanning electron microscopy of the interface revealed the presence of micro-gaps alternating with areas of resin tags.


On the other hand, enamel treated by micro-abrasion acquires a highly polished surface of mineralized tissue. This surface smear layer, 15um thick, has been referred to as the abrasion effect or enamel glaze layer which is considered as the chief advantage of enamel micro-abrasion compared to mechanical stripping (Chan et al; 1995, Train et al; 1996 and Croll; 1996). Moreover, changes in the organic substance, loss of calcium and decrease in microhardness could be potential causes of reduction in the bond strength (McCracken and Haywood; 1996, Hegedus et al; 1999, Guran & Oltu; 2000, Potocnik et al; 2000, Cimilli & Pameijer; 2001, Rodrigues et al; 2001, Basting et al; 2003 and Attin et al; 2004).
surface area for subsequent action of the bleaching agent. This could explain the appearance of deep micro-gaps observed by the SEM (fig 7).

On the other hand, other studies reported that in-office and at-home bleaching did not affect the shear bond strength of orthodontic brackets to enamel (Bishara et al; 2005) and the adhesiveness of resins to enamel is not affected by bleaching (Loretto et al; 2004). It is important to emphasize that the results of these studies could not be compared to our study because the laboratory methods are extremely different namely the photopolymerization light source factor in the former study and the concentration of hydrogen peroxide which was (25%) in the latter. Moreover, the storage of the specimens in artificial saliva could have also played a role in reversing the effects of bleaching (Justino et al; 2004 and Shinkai et al; 2007).

Results of this study demonstrated that bonding of Rely-a bond to human enamel pretreated with combined bleaching then micro-abrasion recorded significantly higher shear bond strength (17.14 MPa) than all other groups tested. SEM findings revealed the presence of more regular resin-enamel interface with very few micro-gaps intermingled with resin tags (fig 6) as compared with micro-abraded then bleached enamel (fig 8).

The variation between the bond strength of the two adhesives tested could be attributed to the difference in the chemical composition. The remineralizing effect of fluorides could account for such improvement in the shear bond strength. This holds true specifically that it was reported that enamel compromised by bleaching could be reversed by the action of remineralizing agents and anti-oxidants (Attin et al; 1997, Lai et al; 2002, Bishara et al; 1993 and 2005, and Bulut et al; 2006). It seemed that the action of fluoride releasing bond coupled with micro-abrasion following bleaching were effective in reversing the adverse effect of bleaching to a certain extent. On the other hand, enamel micro-abrasion followed by bleaching might have resulted in accumulation of multiple oxygen bubbles on enamel surface that could not be compensated by the action of fluorides.

### CONCLUSIONS

1. The sequence of the treatment has an effect on the shear bond strength depending on the type of the adhesive used.

2. When combined bleaching and micro-abrasion therapy is considered before bonding with fluoride releasing bond, it could be advantageous to begin with bleaching procedures, while bonding with adhesives containing organic solvents is not affected by the sequence of the treatment.

3. Fluoride releasing adhesive systems together with subsequent micro-abrasion could reduce or eliminate the adverse effects of bleaching systems so they are recommended for immediate bonding of orthodontic brackets or esthetic composite veneers.

4. The micromorphological features at the tooth restoration interface varied with the different treatments used.

### REFERENCES


