Abstract:

Objective: Application of sodium ascorbate as an antioxidant and calcium hydroxide as a buffering agent following intracoronal bleaching has been recommended. The aim of this study was to investigate the effect of using the mentioned materials on shear bond strength of composite resin to the bleached dentin.

Materials and Methods: In this in vitro investigation, sixty human sound premolars were divided randomly into five groups (n=12). Occlusal dentin surfaces were exposed. The negative control (NC) group was not bleached and the other groups were bleached with 35% hydrogen peroxide gel for 5 days. Afterwards, composite cylinders were built up in the positive control (PC) group immediately after bleaching, in the delay bonding (DB) group after one week, in the sodium ascorbate (SA) and calcium hydroxide (CH) groups after 40 hours of treatment with the materials. Then, the samples were stored in 37°C for 24 hours. The specimens were thermocycled (5-55°C, 500 cycles), subjected to shear bond testing by universal machine. The data were analyzed by One-Way ANOVA and Duncan tests ($\alpha=0.05$).

Results: There was a significant difference between PC and CH groups in comparison with the other groups (p<0.05), but the difference among other groups was not significant (p>0.05).

Conclusion: Application of sodium ascorbate could significantly increase the bond strength of composite resin to bleached dentin, while the use of calcium hydroxide did not affect bond strength.

Key Words: Bleaching; Bond Strength; Antioxidant; Calcium Hydroxide; Composite

INTRODUCTION

Nowadays, patients of all ages all over the world are interested in dental esthetics. In this context, tooth discoloration due to endodontic treatment is one of the most severe problems [1]. Discoloration has occurred in 10% of endodontically treated teeth and there are several options to overcome this problem, among which bleaching is the most conservative option. It has been more than one century that bleaching of endodontically treated teeth has been investigated. An intracoronal bleaching
using 35% hydrogen peroxide in nonvital, discolored teeth with or without sodium perborate has shown objective improvement [2]. Despite obtaining the satisfactory results with bleaching of endodontically treated teeth, some studies discuss the side effects of this therapy, such as decrease in fracture strength of the tooth, external color rebound and decrease of bond strength between restorative materials and dental tissues [3-6].

Some studies have demonstrated that a reduction in bonding strength of composite resin in bleached teeth may be due to the presence of active chemicals from bleaching [5,7-9]. Residual oxygen may be responsible for the inhibition of resin polymerization and increase in resin porosities [8]. Several authors have showed that optimal bond strength may be achieved with a time delay after the bleaching [9-11]. Changes in dental tissues following bleaching is dependent on elapsed time; therefore, delay in bonded restoration placement may solve the difficult situation [2].

If the oxidizing action of hydrogen peroxide is responsible for the decrease of dentin bond strength to composite resin, applying a bio-compatible and neutral antioxidant such as sodium ascorbate before bonding may reverse its effect [12]. Some authors have recommended the use of sodium ascorbate on bleached dentin [7,13].

One of the common side effects of intracoronary bleaching is external root resorption [14]; it is believed that decrease in pH implicates the external root resorption process. Therefore, dressing with calcium hydroxide could prevent it. The theory behind it is based on the buffering potential of calcium hydroxide, which would avoid the decrease in pH caused by bleaching with hydrogen peroxide [2]. The effect of calcium hydroxide on the bond strength of composite resin to bleached dentin has not been demonstrated. However, application of some of it has been recommended in textbooks to avoid external resorption [2,15,16]. Restorative material bond strength to bleached dentin has not been studied thoroughly [17]. The aim of this study was to investigate the effect of using antioxidant and buffering agents on the bond strength of composite resin to intracoronally bleached dentin.

**MATERIALS AND METHODS**

In this experimental study, sixty extracted human sound premolars were selected and stored in 0.2% thymol solution prior to the study. Each tooth was horizontally sectioned approximately 2 mm apically to the cementoenamel junction using a water cooled diamond bur (D&Z, Berlin, Germany). The specimens were mounted in cold-cured acrylic resin (Acropars, Iran) vertically, so their occlusal surfaces were

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean(SD)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>14.05(3.21)</td>
<td>9.48</td>
<td>18.40</td>
</tr>
<tr>
<td>PC</td>
<td>3.02(1.16)</td>
<td>0.14</td>
<td>8.78</td>
</tr>
<tr>
<td>DB</td>
<td>15.72(5.72)</td>
<td>2.83</td>
<td>24.06</td>
</tr>
<tr>
<td>SA</td>
<td>12.55(3.69)</td>
<td>7.64</td>
<td>18.68</td>
</tr>
<tr>
<td>CH</td>
<td>6.71(2.62)</td>
<td>3.11</td>
<td>10.76</td>
</tr>
</tbody>
</table>

NC= Negative Control, PC= Positive Control, DB= Delay Bonding, SA= Sodium Ascorbate, CH= Calcium Hydroxide
faced-up. The occlusal surfaces of the teeth were trimmed by trimmer machine (KaVo, Germany) until their dentin surfaces were exposed and they were then polished with 600 grit silicon carbide paper.

**Bleaching Treatment:**
The specimens were randomly assigned into five groups (n=12). The negative control group (NC) did not receive bleaching treatment and was incubated. The other groups were walking bleached with 35% hydrogen peroxide gel (Hydrogen Peroxide 35%, Opalescent Endo, Ultradent, USA). Clear plastic molds (3 mm diameter×3 mm height) were fixed using sele- fen on each dentinal surface and bleaching gel was injected in it. The bleaching time according to the manufacturer’s recommendations was 5 days and during bleaching time the specimens were incubated at 37°C and 100% humidity. Then the specimens were precisely rinsed with tap water for 1 minute. The positive control group (PC) was bonded immediately after bleaching. The one week delay group (DB) was incubated for 7 days at 37°C and 100% humidity in the incubator (Behdad, Tehran, Iran) and then bonded.

**Application of Antioxidant:**
The sodium ascorbate group (SA) received 10% sodium ascorbate gel for 40 hours (equal to one-third of bleaching time [7]) and then the specimens were rinsed for 1 minute and prepared for the bonding process.

**Application of Calcium Hydroxide:**
In the calcium hydroxide group (CH), the calcium hydroxide paste was prepared from mixing CH powder (Merck, Germany) with normal saline in ratio of 1 scoop/1 drop and was placed on the surface of the specimens and after 40 hours washed thoroughly for 1 minute and prepared for bonding.

**Restorative Procedure:**
All of the specimens were etched with a 35% acid etching gel (Ultra etch, Ultra dent Product, Inc. South Jordan UT 84095) for 15 seconds and then rinsed (10 sec) and air dried (5 sec). Then, Single Bond (3M ,St. Paul, MN, USA) was applied in two layers by means of micro brush and was gently air thinned and then light cured with Blue Phase C5 (Ivoclar Vivadent, Ltd, 12 omega St. Albany) for 10 seconds. After application of the bonding agent, using clear plastic molds (3 mm diame

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Table 2. P-Value of Comparison between Groups Tested (Results of Duncan Test)

<table>
<thead>
<tr>
<th>Groups</th>
<th>CH</th>
<th>SA</th>
<th>DB</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC</td>
<td>0.001*</td>
<td>0.894</td>
<td>0.869</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>PC</td>
<td>0.278</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td>-</td>
</tr>
<tr>
<td>DB</td>
<td>&lt;0.001*</td>
<td>0.326</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SA</td>
<td>0.008*</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*represents significant differences
NC= Negative Control, PC= Positive Control, DB= Delay Bonding, SA= Sodium Ascorbate, CH= Calcium Hydroxide
ter×4 mm height), z100 composite resin (3M ESPE, St. Paul, MN, USA) was bonded. Each composite cylinder was light cured from four directions (three on the sides and one on the end) for 20 seconds altogether.

All specimens were incubated in 37°C and 100% humidity for 24 hours. The molds were removed and the specimens were thermocycled (5-55°C, 500 cycles 20-second dwell time and 10 second transfer time) by an automatic thermocycler (KARA 1000, Tehran, Iran).

**Bond Strength Test:**
The shear bond strength was measured by universal testing machine (Dartec Series HC10, England). A parallel knife-edge shearing device was aligned over the bonded surface near to the interface and the force was loaded to failure, using a crosshead with speed of 1 mm/min. Means and standard deviations were expressed in MPa. The data were analyzed using One-way ANOVA and Duncan tests (α=0.05).

**RESULTS**
The mean, minimum and maximum bond strength and standard deviations of bond strength of each group are shown in Table 1. There were statistically significant differences among the groups (p<0.05). Two by two comparisons of the groups are summarized in Table 2.

**DISCUSSION**
The intracoronal bleaching is the most common and recommended technique for endodontically treated teeth [11]. In the present study, a commercial brand of 35% hydrogen peroxide gel (Opalescent EndoUltradent, USA) was used. This product has been suggested by the manufacturer, especially for walking bleaching. It is important for the restorative procedure following bleaching treatment to gain a pleasant appearance, since the color of composite resin must be compatible with the bleached tooth. Furthermore, adhesion of the composite resin restoration to the tooth should be able to prevent micro leakage and withstand the forces exerted during mastication [11]. Several researches have shown that the bleaching agent interferes with the adhesion of composite resin restoration to dental tissues and also contributes to the susceptibility of the tooth surface to micro leakage [18-20]. Most studies have shown that bleaching may adversely affect bond strength of the adhesive material to the enamel and dentin [11, 21-23]. The results of NC and PC groups are in accordance with the previous studies. Lai et al found that the residual solution in collagen matrix and dentinal tubules that occasionally break down to oxygen and water may lead to reduction in the bond strength in hydrogen peroxide treated dentin. Some other studies have suggested that decrease in bond strength may be due to bleaching residues inhibiting resin polymerization and the released oxygen could interfere with resin penetration into the etched enamel [8,23,24]. Rostein et al showed that most bleaching agents cause changes in the level of calcium, phosphorus, sulfur and potassium in the tooth tissue. Changes in Ca to P ratio indicate alternations in the organic components of hydroxyapatite [25]. It seems that bleaching agents may adversely affect the dental hard tissue. Perinka et al have indicated that dentinal characteristics such as thickness, hardness and calcium concentration might influence the bond strength to dentin [26]. Moreover, physical properties of dentin are related to the distance from the pulp. The effect of the bleaching agent in intracoronal bleaching is likely to be more pronounced in the inner dentin, decreasing as it approaches the dentinoenamel or dentinocemental junction [11]. In this study, superficial dentin was only evaluated which is one of the limitations of the
The present study. Several studies have demonstrated that optimal bond strength may be achieved with a time delay after the bleaching [9-11,27].

The present investigation showed that a period of 7 days after bleaching is sufficient to obtain adequate shear bond strength of composite resin to bleached dentin.

Potent antioxidants such as ascorbic acid and its sodium salts may extinguish reactive free radicals in biological environments [28]. The antioxidant ability of sodium ascorbate can help to neutralize and reverse the oxidizing effects of hydrogen peroxide in biological systems [7]. This study confirmed the mentioned results, when the SA group demonstrated almost the same bond strength to the NC group.

Bleaching of endodontically treated teeth causes external root resorption [2]. However, it may be prevented by placing a base in the root-canal orifice [3]. In the pulp chamber, applying calcium hydroxide as temporary dressing material has also been shown to prevent external root resorption [2]. Kehoe showed that bleaching agents decreased the pH in the cementoenamel junction and stimulated osteoclastic activity which could start external root resorption [29].

The main property of calcium hydroxide-based materials is the high pH they produce on the neighboring surroundings [30]. Filling the pulp chamber with calcium hydroxide paste may raise the pH and therefore prevent osteoclastic activity [29]. It has been shown that if calcium hydroxide remains on the cavity wall, it could increase microleakage [31]. Demarco et al showed that temporary dressing of the pulp chamber with calcium hydroxide had no effect on microleakage and that this type of dressing after bleaching did not affect the adhesive capacity of the dentin bonding agent tested. Maybe, acid etching removes the calcium hydroxide remnants from the surface eliminating any adverse effect of the substance on coherence [2].

These findings seem to be due to the margins of access cavity which were limited to enamel and had no direct contact either with the bleaching agent or calcium hydroxide; another study demonstrated that nonvital bleaching increases microleakage in restorations with dentin margins, but not in those with enamel margins [11].

In this study, results of the CH group show considerable reduction of bond strength compared to nonbleached, delay bonding and sodium ascorbate groups. It seems that the simple rinsing of calcium hydroxide is not enough to eliminate its effects.

Future studies related to the effect of the material and suitable rinsing agents are recommended.

CONCLUSION

In conclusion, the present study showed that bleaching had an adverse effect on the shear bond strength of composite resin to dentin. Both one week delay and antioxidant treatment could increase the bond strength as high as the nonbleached group. However, application of calcium hydroxide paste as a buffering agent decreased the bond strength to the level of immediate bonding after bleaching.

AKNOWLEDGMENTS

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