Effect of Two Forms of Sodium Ascorbate on Microleakage of Composite Restorations Immediately after Bleaching


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Abstract:
Objective: The present in vitro study was undertaken to compare the effects of hydrogel and solution forms of sodium ascorbate on microleakage of composite restorations subsequent to a non-vital bleaching procedure with 10% carbamide peroxide.

Materials and Methods: Forty-eight sound extracted human maxillary incisors were obtained. Following root canal therapy, the teeth were randomly divided into an unbleached control group (group 1) and three experimental groups in which bleaching was performed (12 teeth in each group). Non-vital bleaching with 10% carbamide peroxide was carried out for periods of 8 hours a day for one week. In group 2, the specimens were restored immediately after bleaching. Group 3 specimens were treated with sodium ascorbate solution, whereas in group 4 specimens, sodium ascorbate hydrogel was used before placement of composite restorations. Following thermocycling, the specimens were subjected to dye leakage (methylene blue) test. Statistical analysis was carried out using Kruskal-Wallis and Dunn multiple comparison tests at a significance level of P<0.05.

Results: Significant differences existed in microleakage scores among the four groups (P<0.0005). Pairwise comparison of groups with Dunn test revealed that higher microleakage scores in group 2 compared to each of the other three groups was statistically significant (P<0.001) while the differences between other groups were not statistically significant (P>0.05).

Conclusion: Ten percent carbamide peroxide significantly increases microleakage of composite restorations when bonding is performed immediately following non-vital bleaching. Compromised sealing ability of composite restorations is reversed with application of both forms (hydrogel and solution) of sodium ascorbate, as an anti-oxidant.

Key Words: Tooth Bleaching; Composite Resins; Dental Leakage; Hydrogel; Ascorbic Acid; Marginal Adaptation (Dentistry)

INTRODUCTION
Ten percent of teeth undergoing root canal therapy show tooth discoloration, which results in aesthetic problems [1]. Non-vital bleaching is used successfully for whitening of root-filled teeth [2]. One of the non-vital bleaching methods is walking technique using 10% carbamide peroxide [3]. However, previous studies have shown that bleaching agents adversely affect the bond strength and sealing ability of composite restorations when bonding procedure is performed immediately after
bleaching [4]. This detrimental effect might be attributed to the possible presence of residual peroxide in enamel and dentin, which interferes with resin attachment and inhibits resin polymerization [5]. It has been reported that it takes 1 to 4 weeks for tooth structure to return to conditions leading to normal bond strength and sealing ability, which may necessitate postponement of the treatment [4,6].

Recently, it has been demonstrated that compromised sealing ability of composite restorations can be reversed through application of 10% sodium ascorbate solution as an antioxidant before restoration. Furthermore, in a study it was reported that this technique improved the reduced sealing ability of resin composite restorations more than the method in which there was a one-week delay in restorative procedure subsequent to bleaching [4]. In previous investigations, sodium ascorbate has been used in its solution from [4,7,8]. However, the gel form of sodium ascorbate is easy to apply (because of its higher viscosity and better control) and its application is less expensive for patients compared to the application of sodium ascorbate solution by the dental practitioner due to the shorter chair time needed [9].

In addition, the solution should be used several times prior to bonding [10]. Patients themselves can place the gel form of sodium ascorbate in the bleaching tray before bonding, which can decrease chair time [8,9].

The present study compared the effect of the solution and hydrogel forms of sodium ascorbate on microleakage of composite restorations immediately following non-vital bleaching.

**MATERIALS AND METHODS**

Forty-eight sound extracted human upper maxillary central incisors were selected for the purpose of this *in vitro* study. The teeth had been extracted for periodontal reasons were caries-free, and had no previous restorations or pre-existing fractures or cracks, when surveyed under a stereomicroscope (Olympus SZX9; Olympus, Tokyo, Japan). Subsequent to extraction, the teeth were cleaned of any residues and stored in 0.5% chloramine trihydrate at 4°C for infection control.

Endodontic access cavities were prepared 3 mm in a diameter using a round diamond bur [1.4 mm diameter] (SS White Burs, Inc. Lakewood, NJ, USA) in a high-speed handpiece under cooling with air/water. During tooth preparation, each tooth was wrapped in a piece of water-moistened gauze. Used burs were replaced with new burs after every five preparations. Each canal was prepared up to 1 mm short of the radiographic apex. Using K-files (MANI, Inc, Tochigi, Japan), we instrumented root canal of each tooth with passive step-back technique to file #35 at the apical constriction. Prepared canals then were obturated with gutta-percha and AH 26 root canal sealer (Dentsply, DETREY, GmbH, Konstanz, Germany) and with lateral condensation technique. Following removal of the gutta-percha to a level 2 mm apical to the buccal cemento-enamel junction, light-cured glass ionomer base (Fuji II LC, GC, Tokyo, Japan) with 2 mm thickness was placed. The specimens were randomly divided into four groups of 12 teeth each (n=12). Each group was treated as shown in Table 1.

**Table 1.** Detailed description of different treatments in the study groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Bleaching Treatment</th>
<th>Antioxidant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>10% carbamide peroxide gel</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>10% carbamide peroxide gel</td>
<td>10% sodium ascorbate solution</td>
</tr>
<tr>
<td>4</td>
<td>10% carbamide peroxide gel</td>
<td>10% sodium ascorbate hydrogel</td>
</tr>
</tbody>
</table>
Bleaching
In groups 2-4, 10% carbamide peroxide bleaching gel (Opalescence, Ultradent Products, Inc, USA) was placed into the pulp chamber and the access cavity so that it would extend onto the lingual surface for eight hours per day. The specimens were partially immersed in artificial saliva at 37°C in a glass laboratory beaker so that bleaching gel did not contact saliva. After the daily bleaching process, the specimens were thoroughly rinsed with water and air-dried. For the rest of the day the teeth were stored in artificial saliva at 37°C. The artificial saliva consisted of 1 g sodium carboxymethylcellulose, 4.3 g xylitol, 0.1 g potassium chloride, 5 mg calcium chloride, 40 mg potassium phosphate, 1 mg potassium thiocyanate and 100 g distilled deionized water [4]. The artificial saliva was changed twice daily. After removing the teeth from the artificial saliva, specimens were rinsed with water for 30 seconds. The bleaching procedure was continued for one week. In group 1 (control), the specimens were not bleached.

Preparation of the Solution and Hydrogel
Carbomer (Carbopol 934) was supplied by Noveon (Brussels, Belgium). Sodium ascorbate (L (+) Ascorbic acid sodium salt) was obtained from Fluka (Buchs, Switzerland). All other chemicals were of analytical grade. To prepare solution containing sodium ascorbate (10%), sodium ascorbate was dissolved in purified water under mixing at room temperature (pH=7.5). The carbopol gel (2.5% wt/wt) containing sodium ascorbate (10%) was prepared by dispersing the carbopol resin in purified water containing sodium ascorbate under gentle mixing. The mixture was stirred until thickening occurred and then neutralized by drop-wise addition of triethanolamine until a transparent gel appeared. The quantity of triethanolamine was adjusted to achieve a gel pH of 7.

Application of Antioxidant
Subsequent to completion of bleaching procedure, the samples in group 3 were immersed in 10% sodium ascorbate solution for three hours. Ten percent sodium ascorbate hydrogel was placed inside the pulp chamber and the access cavity for three hours at 100% relative humidity in group 4. Then the samples were rinsed with distilled water for 30 seconds and gently air-dried.

Composite Restoration
Access cavities and pulp chambers were etched with 35% phosphoric acid (Scotchbond TM Etchant, 3M Dental Products, St. Paul, MN, USA) for 15 seconds. After rinsing and removing the excess water, bonding agent (Adper Single Bond, 3M Dental Products) was applied according to manufacturer's instruc-

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Table 2. The materials used in the present study.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Manufacturer</th>
<th>Compositions</th>
<th>Batch No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opalescence</td>
<td>Ultradent Products Inc, USA</td>
<td>10 % carbamide peroxide bleaching gel</td>
<td>B2CQ8</td>
</tr>
<tr>
<td>Scotchbond™ Etchant</td>
<td>3M Dental Products, St. Paul, MN, USA</td>
<td>35% phosphoric acid</td>
<td>7JN</td>
</tr>
<tr>
<td>Adper Single Bond</td>
<td>3M Dental Products, St. Paul, MN, USA</td>
<td>Light-cured adhesive system containing 2-HEMA, Bis-GMA, Amine di-methacrylate, Polyalkanoic acid, Itonaic acid, Ethanol, Water</td>
<td>6KR</td>
</tr>
<tr>
<td>Z100</td>
<td>3M Dental Products, St. Paul, MN, USA</td>
<td>Light-cured composite resin, radiopaque, containing zirconia/ silica filler (60% wt – particle size range 0.01- 3.5 μm), Bis-GMA, TEGDMA</td>
<td>5YA</td>
</tr>
</tbody>
</table>
tions and cured for 10 seconds using an Astralis 7 light-curing unit (Ivoclar Vivadent, Amherst, NY, USA) adjusted to 400 mW/cm². Resin composite [A3] (Filtek Z100, 3M Dental Products) was placed and polymerized using incremental technique (in three layers). Each layer was light-cured for 40 seconds. After finishing with finishing diamond burs (Diamant GmbH, D & Z, Goerzallee, Berlin, Germany) and finishing disks (Sof-LexTM, 3M ESPE, Dental Products), the specimens were stored in distilled water at 37 °C for one week, and thermocycled at 5°C (SD=5) / 55°C (SD=5) (500 times) with a dwell time of 30 seconds and 10 seconds for specimen transfer.

Microleakage Assessment
The apices of the teeth were sealed with utility wax, and all tooth surfaces were covered with two coats of nail polish with the exception of 1 mm around the tooth-restoration interface. The teeth were immersed in 0.5% methylene blue for 8 hours. Then the specimens were removed, rinsed with tap water, and sectioned with a diamond disk (D & Z Diamant GmbH, Berlin, Germany) along the bucco-lingual direction corresponding to the center of the restoration. All samples were prepared by one operator. Two examiners evaluated both hemi-sections of each tooth at magnification ×20 under a stereomicroscope for dye penetration. The examiners were blind to which group the teeth belonged. Microleakage was scored on a 0 to 3 scale [4]:

0: No dye penetration
1: Dye penetration up to half of the cavity depth
2: Dye penetration greater than scale I without involvement of gutta-percha
3: Dye penetration with involvement of gutta-percha

Any discrepancies between the two main examiners were reevaluated, and when necessary a third examiner decided on the score. Statistical analysis was carried out using the Kruskal-Wallis, and two-by-two comparisons were made by the Dunn test at a significance level of P<0.05.

RESULTS
Microleakage scores obtained from four groups have been shown in Table 3. Kruskal-Wallis analysis indicated significant differences in microleakage scores among the four groups ($\chi^2=25.07$, df=3, P<0.0005). Pairwise comparison of groups with Dunn test revealed that higher microleakage scores in group 2 compared to each of the other three groups were statistically significant (P<0.001), while the differences between other groups were not statistically significant (P>0.05).

DISCUSSION
Increased microleakage impairs the long-term

<table>
<thead>
<tr>
<th>Groups</th>
<th>Microleakage Scores</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Group 1: No Bleaching</td>
<td>9</td>
</tr>
<tr>
<td>Group 2: Bleaching</td>
<td>0</td>
</tr>
<tr>
<td>Group 3: Bleaching</td>
<td>5</td>
</tr>
<tr>
<td>Group 4: Bleaching</td>
<td>7</td>
</tr>
</tbody>
</table>

Microleakage Scores (0: No dye penetration; 1: Dye penetration up to half of the cavity depth; 2: Dye penetration greater than scale I without involvement of gutta-percha; 3: Dye penetration with involvement of gutta-percha)
success of both the bleaching procedure and the endodontic treatment [4]. According to the results of the present study bleaching with 10% carbamide peroxide (group 2) resulted in a significant increase in microleakage compared to the unbleached group (group 1) when the bonding procedure was performed immediately following bleaching. The results of our study coincide with previous investigations [5,11,12]. These findings might be attributed to the poor bonding between composite restoration and the tooth structure, since in numerous studies decreased bond strength of composite resin to the enamel and dentin have been shown when the bonding procedure has been performed immediately after bleaching with carbamide peroxide [13,14]. Furthermore, increased microleakage might be due to enamel structure changes, loss of calcium, microhardness decrease, loss of prismatic formation and alterations in the organic substrate, which might result in a decrease in enamel bond strength and marginal sealing [15-19]. In addition, it has been claimed that the residual oxygen from the bleaching agent interferes with resin infiltration into the tooth structure and inhibits resin polymerization [20,21]. Inadequate penetration and polymerization of resin base materials can lead to poor adhesion between resinous materials and tooth structure [8]. Moreover, in a study carried out by Titley et al [22] there were less resin tags and less penetration depth of those resin tags in bleached enamel compared to unbleached enamel under SEM evaluation. Based on the reports of Dishman et al [23] the bonding efficacy of resin composite to bleached enamel can be compromised with the fewer number of resin tags.

The results of the current study revealed that microleakage of composite restorations decreased significantly following anti-oxidant application (hydrogel and solution of sodium ascorbate) in comparison with group 2 (without anti-oxidant treatment). This decreased microleakage was comparable to that in the control group. These results concur with those of Türkün et al [4], who reported that reduced sealing ability of composite restorations is reversed by the use of 10% sodium ascorbate solution. In addition, some studies have demonstrated that reduced enamel and dentin bond strength significantly improves by sodium ascorbate application [24,25]. Decreased microleakage and improved adhesion between resin composite and tooth structure might be attributed to anti-oxidizing ability of sodium ascorbate. Ascorbic acid and its sodium salt are potent anti-oxidants capable of quenching reactive free radicals in biological systems [26]. Zhao et al [27] reported that following tooth bleaching with carbamide peroxide hydroxyl radicals in the apatite lattice were substituted by peroxide ions of carbamide peroxide and produce peroxide-apatite. When the peroxide ions decompose, substituted hydroxyl radicals enter the apatite lattice, resulting in the elimination of the structural changes caused by the incorporation of peroxide ions [28]. Furthermore, it has been reported that sodium ascorbate allows free-radical polymerization of resin base materials to proceed without premature termination by restoring the altered redox potential of the oxidized bonding substrate, thus reversing the compromised bonding [7].

According to the results of this study, there were no significant differences in microleakage scores between two forms of sodium ascorbate (hydrogel and solution). These findings are consistent with those of previous studies [9, 10], which have shown that both forms of sodium ascorbate act similarly in increasing bond strength following bleaching. Therefore, it is suggested that sodium ascorbate hydrogel might be as effective as solution form of sodium ascorbate in decreasing microleakage of composite restorations following non-vital bleaching.

None of the specimens showed the highest mi-
Microleakage scores (score 3) in our study. This might be attributed to the placement of glass ionomer base. In previous investigations, the preventive effects of glass ionomer base over the gutta-percha on coronal microleakage have been proved [4, 29].

Future studies should evaluate microleakage using three-dimensional methods and scanning electron microscope (SEM) to provide additional information. Moreover, further research are required to determine the minimal time necessary for sodium ascorbate hydrogel to neutralize the oxidative effects of bleaching material.

CONCLUSION
Within the limitations of this study, it was concluded that: Bleaching with 10% carbamide peroxide significantly increased the microleakage of composite restorations when the bonding procedure was performed immediately after bleaching. Application of both forms of 10% sodium ascorbate after bleaching reversed the sealing ability of composite restorations to the level of unbleached group. No significant differences existed in microleakage scores between both forms (hydrogel and solution) of sodium ascorbate.

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