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Original Article

The effects of antioxidant application and time factor on fiber post bonding to root dentin after intracoronal bleaching

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Abstract

Aim: The aim was to evaluate the effects of antioxidant application and delayed cementation on the bond strength of fiber posts after intracoronal bleaching.
Methodology: Fifty-five maxillary central incisors were used. Root canals were enlarged using Reciproc system up to R40 instrument. Root canals were irrigated, dried with paper-points, and obturated with gutta-percha and a sealer. In 44 teeth, root canal fillings were removed 2-mm coronally and canal orifices were sealed with glass-ionomer-cement. A 37% carbamide peroxide (CP) gel was used to bleach the teeth. Five experimental groups were defined (n=11). G1: No bleaching, G2: Immediate fiber post cementation (FPC), G3: Immediate FPC after sodium ascorbate (SA) application, G4: 14-days delayed FPC, G5: 14-days delayed FPC after SA application. Push-out tests were performed. Statistical interpretations were made ($\alpha=0.05$).
Results: There was no significant difference among the groups in apical thirds ($p>0.05$). However, significant differences were detected among the groups in middle and coronal thirds ($p<0.05$).
Conclusions: The 14-days delayed cementation seems to be a more reliable method than the SA application before FPC procedure after intracoronal bleaching.

Keywords: Internal bleaching, devital bleaching, antioxidant application, sodium ascorbate, delayed cementation, push-out.

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Introduction

Endodontically treated teeth may require intracoronal bleaching before coronal reconstruction with fiber posts to obtain satisfactory aesthetic results. To solubilize or decolorize the chromogens via oxidation, hydrogen peroxide, sodium percarbonate, sodium perborate, and carbamide peroxide (CP) can be used as bleaching agents (1). However, they may cause alterations in the enamel and dentin tissue, such as porosity (2), demineralization (3—5), and a reduction in the adhesion of the restorative materials (6, 7). In order to overcome these problems, the use of antioxidants and the delayed cementation of fiber posts have been recommended (8, 9). However, the data in the literature is contradictory, and there is no consensus about their effectiveness (10—13).

Endodontically treated teeth with wide losses of tooth structure require fiber posts for restoration retention (14). Various studies have shown that the adhesive failures associated with fiber posts usually occur along the bonding-dentin interface (15—17). Therefore, resin cements are used to improve the adaptation of the circular posts to the canal walls. In the literature, the radicular peroxide penetration from carbamide peroxide gels applied during intracoronal bleaching has been shown (18). In addition, glass-ionomer cements, which are used as a protective barrier, may not prevent the leakage of bleaching agents; thus, the bonding strength of the fiber post may decrease (19). Therefore, the aim of this study was to analyze the effects of the antioxidant application and delayed fiber post cementation (FPC) on the push-out bond strength after intracoronal bleaching. The tested null hypothesis that there was no significant difference among the groups with regard to the push-out bond strength.

Materials and Methods

After obtaining approval from the local ethic committee (Decision no: 2017/473), 55 human central incisor teeth with intact crowns and similar root sizes and lengths (approximately 13-mm) were selected. In each tooth, the access cavities were prepared and the root canal preparations were performed using the RECIPROC system (VDW, Munich, Germany) up to a size R40 instrument. After each instrument change, the root canals were irrigated with 2 ml of 2.5% NaOCl solution using a 30-gauge needle. For the final irrigation, 10 ml of 5% NaOCl and 3 ml of distilled water were used for each canal. The root canals were dried with absorbent paper points. Then, gutta-percha (DiaDent Group International, Chungcheongbuk-do, Korea) and AH Plus (Dentsply DeTrey GmbH, Konstanz, Germany) root canal sealers were used to fill the root canals via the cold lateral compaction technique, and the access cavities were covered with a temporary filling material (Cavit G; 3M ESPE, Seefeld, Germany). Next, the teeth were stored at 37°C in 100% humidity for 7 days for the complete setting of the root canal sealer. After the sealer was set, the temporary fillings were removed from each tooth and the root canal fillings were shortened 2 mm subgingivally from the cementoenamel junction. Finally, glass ionomer cement (Fuji IX GP; GC Corp., Tokyo, Japan) was laid on the root canal fillings as a protective barrier. The specimens were randomly distributed into 5 groups (n=11), as follows:

Group 1: No bleaching, and FPC (control group).

Group 2: Bleaching with 37% CP gel (Whiteness Super Endo; Dentscare Ltda, Joinville, Brazil) and immediate FPC.

Group 3: Bleaching with 37% CP gel and immediate FPC after the application of 10% sodium ascorbate (SA) for 10 minutes.

Group 4: Bleaching with 37% CP gel, with FPC delayed for 14 days.

Group 5: Bleaching with 37% CP gel, with FPC delayed for 14 days after the application of 10% SA for 10 minutes.

The bleaching process was carried out as follows: first, the pulpal cavities of the teeth were washed and dried; then, the 37% CP bleaching gel was inserted into the cavities. Next, a piece of cotton was placed on the bleaching agent, and the access cavities were sealed with glass-ionomer cement (Fuji IX GP). The CP gel was renewed twice, at three-day intervals. The teeth were stored in distilled water (37°C±1°) during the waiting time for the bleaching. After a total of 9 days, the intracoronal bleaching procedures were ended in all the teeth. The remnants of the bleaching procedures were cleaned from the access cavities before the FPC procedures. The bleaching procedure was not applied to the control group.

The post spaces were prepared with fiber post preparation drills (Size #1 fiber post drill, D.T. Light-Post; Bisco Inc., Schaumburg, IL, USA) to a length of 10-mm from the cementoenamel junction. The post spaces were irrigated using EDTA in combination with ultrasonic activation, hypochlorite, and saline solution, and they were dried with paper points. In groups 3 and 5, the 10% SA solution drops were applied for 10 minutes, with a thin microbrush used on the dentinal surfaces of the access cavities and the root dentin surfaces (Fig. 1). Finally, the teeth were washed and dried.

The Panavia F 2.0 (Kuraray, Osaka, Japan) resin cement was prepared according to the manufacturer's instructions. The resin cement was placed in the post spaces using a Lentulo spiral, and the fiber posts (Size #1 fiber post, D.T. Light-Post; Bisco Inc., Schaumburg, IL, USA) were coated with cement and placed in the post spaces. The posts were cemented 10-mm in length from the cementoenamel junction. The resin cement was polymerized for 40 seconds using a light-polymerizing device (Elipar S10; 3M ESPE, Seefeld, Germany).

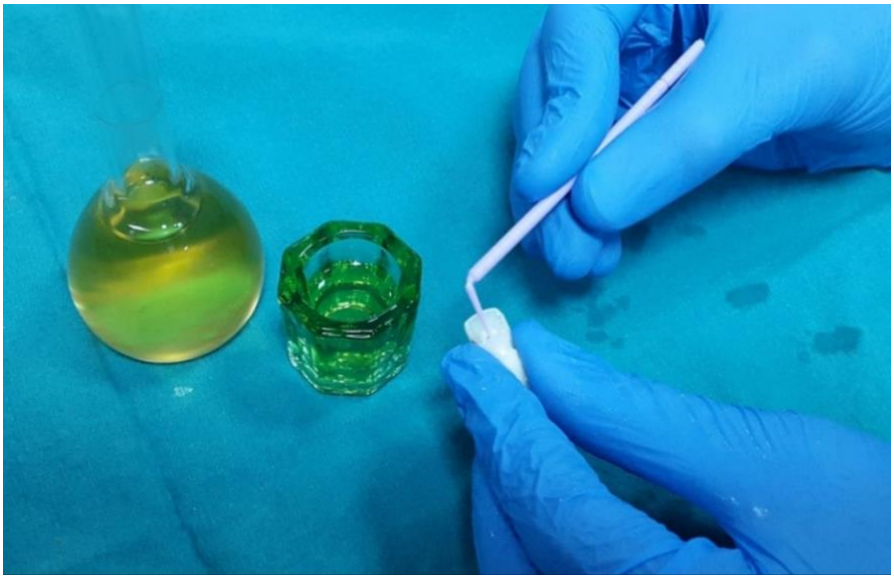

Figure 1. The application of 10% SA onto the coronal and root dentin by using a thin microbrush for 10 min.

The teeth were stored at 37°C and 100% humidity before testing. Each root was cut horizontally using a slow-speed diamond saw (IsoMet; Buehler, Lake Bluff, IL, USA) to obtain three 1-mm-thick specimens (apical, middle, and coronal). A stainless steel cylindrical plunger (diameter of 1, 0.8, or 0.6 mm for the coronal, middle, and apical thirds, respectively) was chosen, and the specimens were loaded from the apical to the coronal direction. The push-out tests were performed at a cross-head speed of 0.5 mm/min using a universal testing machine (Instron, Canton, MA, USA) until dislodgement occurred. The force needed to dislodge the fiber post was recorded in Newtons (N). The dislodgement forces were transformed into megapascals (tension, MPa), and the following formula was used for this purpose: MPa=F/π(R+r)g (20).

After completing the push-out test, the loaded slices were examined under an operating microscope (OPMI Pico; Carl Zeiss, Oberkochen, Germany) at 10x magnification to evaluate the failure modes. The failure mode criteria were an adhesive failure (dentin surface free of sealer), cohesive failure (dentin surface covered by sealer), and mixed failure (a mixture of the adhesive and cohesive failure modes).

Statistical Analysis

The data were statistically assessed (SPSS 20.0; SPSS Inc., Chicago, IL, USA) using a two-way analysis of variance (ANOVA) (antioxidant usage and delayed cementation factors). The one-way ANOVA and Tukey's post-hoc tests were used to make the pairwise comparisons among the groups (α=0.05). The failure modes of the groups were analyzed in percentages.

Results

The two-way ANOVA results showed that, while the delay time affected the bond strengths of the fiber posts, the SA application did not (Table 1). The mean values, standard deviations, and statistical comparisons of the tested groups are given in Table 2. The failure mode frequencies of the groups according to the root regions are shown in Table 3.

Table 1. Two-way ANOVA results showing the effect of delaying time and sodium ascorbate application factors on push-out bond strengths.

	Sum of Squares	F	Sig.
Delaying time	230,036	33,947	0,000
Sodium ascorbate application	4,041	0,596	0,441

Table 2. Mean values and standard deviations of the tested groups according to the root regions. Significantly different groups are shown with different superscript letters.

	Group 1 (No Bleaching)	Group 2 (Immediate, No SA)	Group 3 (Immediate, SA)	Group 4 (Delayed, No SA)	Group 5 (Delayed, SA)	*p* value
Apical	7,66 ± 1,95 ^{A}	6,62 ± 3,23 ^{A}	6,85 ± 2,55 ^{A}	7,08 ± 2,53 ^{A}	7,50 ± 2,90 ^{A}	*0,88*
Middle	9,85 ± 2,66 ^{X}	6,77 ± 1,21 ^{Y}	7,02 ± 2,83 ^{Y}	10,67 ± 1,54 ^{X}	9,53 ± 0,83 ^{X}	*<0,001*
Coronal	12,90 ± 2,25 ^{M}	6,47 ± 1,58 ^{N}	8,92 ± 2,48 ^{P}	11,72 ± 1,31 ^{M}	11,82 ± 1,75 ^{M}	*<0,001*

Table 3. Failure mode frequencies of the tested groups and root regions.

	Adhesive	Cohesive	Mix
Group 1 (No Bleaching) Apical	2 (18,1)	4 (36,4)	5 (45,5)
Group 1 (No Bleaching) Middle	1 (9,1)	6 (54,5)	4 (36,4)
Group 1 (No Bleaching) Coronal	2 (18,1)	4 (36,4)	5 (45,5)
Group 2 (Immediate, No SA) Apical	3 (27,2)	4 (36,4)	4 (36,4)
Group 2 (Immediate, No SA) Middle	7 (63,8)	2 (18,1)	2 (18,1)
Group 2 (Immediate, No SA) Coronal	7 (63,8)	3 (27,2)	1 (9,1)
Group 3 (Immediate, SA) Apical	2 (18,1)	3 (27,2)	6 (54,5)
Group 3 (Immediate, SA) Middle	6 (54,5)	3 (27,2)	2 (18,1)
Group 3 (Immediate, SA) Coronal	7 (63,8)	2 (18,1)	2 (18,1)
Group 4 (Delayed, No SA) Apical	2 (18,1)	3 (27,2)	6 (54,5)
Group 4 (Delayed, No SA) Middle	2 (18,1)	6 (54,5)	3 (27,2)
Group 4 (Delayed, No SA) Coronal	1 (9,1)	5 (45,5)	5 (45,5)
Group 5 (Delayed, SA) Apical	2 (18,1)	5 (45,5)	4 (36,4)
Group 5 (Delayed, SA) Middle	1 (9,1)	7 (63,8)	3 (27,2)
Group 5 (Delayed, SA) Coronal	2 (18,1)	7 (63,8)	2 (18,1)

The percentages were given in parentheses.

Discussion

In this study, 37% CP was used for bleaching the crowns. CP, according to its concentration (10%, 16%, 35%, 37%, etc.), is effective for bleaching both vital and nonvital teeth (21). Its effectiveness depends mainly on the chemical oxidation process (22); however, the oxidizing agents can reduce the adhesion of the resin materials to the dentin (1). Gökay et al. reported the radicular peroxide penetration from CP during an intracoronal bleaching procedure (18). The results showed that the root dentin's peroxide penetration may reduce the bonding strength of the fiber posts to the canal walls. Therefore, the effect of CP on the fiber post bond strength was evaluated in this study.

SA is a salt form of ascorbic acid, and it is a potent antioxidant that can eliminate free radicals in biological systems (11). The application of SA after the bleaching procedure can effectively reverse the bond strength to the dentin (23, 24) and enamel to that of the unbleached state (25). Therefore, in this study, the SA was evaluated for reversing the negative effects of the bleaching agent. In previous studies, it has been shown that an SA application resulted in higher bonding strengths after nonvital bleaching procedures (9—12). Besides the use of antioxidants, delayed bonding or cementation procedures have also been studied; however, there is contradictory information in the literature on this subject. Some authors have advocated the delayed bonding of restorative materials (8, 11, 13, 26), but no positive effect from the delayed bonding on the bonding strength was reported (12). Therefore, 14-day delayed cementation was assessed in this study to clarify this. One important point is that all of these previous studies evaluated the bonding strengths in the enamel or dentin tissue in tooth crowns. This study was different in that it evaluated the fiber post bonding strengths in the root dentin. In this respect, it was not comparable to previous studies.

According to the two-way ANOVA results (Table 1), the SA application did not significantly affect the bonding strengths of the fiber posts. This finding was contradictory with the literature (9, 11, 12). In this study, the SA application was performed in the post spaces in the root canal, which differs from the other studies. Moreover, according to the results, the delayed cementation affected the bonding strengths of the fiber posts (Table 1). This finding is in accordance with the majority of the studies in the literature (8, 11, 13). Therefore, FPC procedures should be delayed following tooth bleaching.

In the coronal root region, the minimum bonding strengths were seen in the fiber posts cemented immediately without the application of SA (Group 2), followed by the fiber posts cemented immediately with the application of SA (Group 3). The 14-day delay groups showed bond strengths similar to those of the control group (no bleaching), and the SA application seemed to have no further effect on the push-out bond strengths in the delayed cementation groups. In the middle root region, the immediate cementation groups (Groups 2 and 3) showed significantly lower bonding strengths than the other groups, and there was no significant difference among the 14-day delayed cementation groups (Groups 4 and 5) and the control group (no bleaching). According to these findings, the main factor that affected the bonding strength was the cementation time delay in this study. It can be argued that the oxygen radicals might penetrate deeper into the root regions when the lower bonding strengths of the fiber posts cemented immediately after the bleaching process are taken into account. In the literature, it has been shown that the oxygen radicals can penetrate into the dentin tubules (18). Additionally, one previous study reported that the glass-ionomer cement, which acts as a barrier, may not prevent the leakage of the bleaching agent (19). In the apical root region, all the experimental groups showed results similar to those of the control group. This could be associated with the further distance between the fiber post's apical area and the intracoronal bleaching site. In this case, the bleaching agent might not penetrate into the deeper areas of the root canal system.

According to the failure mode analysis, the adhesive failure modes were seen especially in the immediate cementation groups, regardless of the SA application. In addition, the cohesive and mixed failure modes were frequently seen in the control group and delayed cementation groups (Table 3). These findings could be related to the lower bonding strength values of the fiber posts in the immediate cementation groups.

Conclusions

After intracoronal bleaching with 37% CP gel, the bonding strength of the fiber post decreased. The 14-day delayed cementation seems to be a more reliable method than the SA application before an FPC procedure, after intracoronal bleaching, to enhance the bonding strength.

Ethical Approval: Ethics committee approval was received for this study from Erciyes University Local Ethic Committee. (Decision No: 2017/473).

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