

## Comparative evaluation of the effects of sodium ascorbate, alcohol, and calcium hydroxide on the bond strength of composite resin to dentin in non-vital teeth bleaching

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### Abstract

**Aim:** The aim of this in vitro study was to investigate the effects of sodium ascorbate, alcohol, and calcium hydroxide as a buffering agent on composite resin-dentin bond strength of non-vital teeth bleaching.

**Methodology:** For our study, we used 80 human upper central teeth. An endodontic access cavity was opened on the palatal surface of the teeth. The root portion of the teeth was removed 2-3 mm below the enamel-cementum junction. Sodium perborate was used for the nonvital bleaching of all teeth. Following bleaching, four experimental groups were created: sodium ascorbate, alcohol, calcium hydroxide, and a control group. 1x1 mm specimens were obtained using a precision cutting device in all four experimental groups restored with bond and composite resin. The specimens were then subjected to tension tests in a microtensile device, and the resulting data were compared in terms of composite resin-dentin bond strength.

**Results:** The study data were analyzed using the Kruskal-Wallis H test due to non-normal distributions of variables to compare groups. If the Kruskal-Wallis test indicated significant differences, a post-hoc multiple-comparison test was used to identify which groups differed. The Shapiro-Wilk test was used to determine whether the variables followed a normal distribution, based on the number of units. A statistically significant difference in binding strength was found between the study groups ( $p<0.05$ ). Specifically, the binding strength value of the sodium ascorbate group was significantly higher than that of the calcium hydroxide and control groups ( $p<0.05$ ). However, no statistically significant difference was observed between the other groups.

**Conclusion:** After non-vital bleaching, sodium ascorbate can be used to improve the bond strength between composite resin and dentin. Further studies are needed to support the effect of alcohol and calcium hydroxide applications on bond strength.

**Keywords:** non-vital bleaching, bond strength, sodium perborate, sodium ascorbate, alcohol, calcium hydroxide

## Introduction

In endodontics, bleaching of internal tooth discoloration has become a current and practical application, in addition to the elimination of infection and pain (1). Internal discoloration can be easily, economically, and conservatively removed using non-vital bleaching techniques (2). In the bleaching technique applied to non-vital teeth, the material placed in the pulp chamber of endodontically treated teeth diffuses from the dentin to the enamel. Common bleaching agents include a mixture of sodium perborate and water, hydrogen peroxide, or a combination of sodium perborate and hydrogen peroxide (3).

Although bleaching has positive aesthetic effects, it can also have negative effects. One of these is that peroxide-based bleaching agents reduce the bond strength of composite resin to enamel and dentin (4). Residual oxygen has been reported to negatively affect bond strength because it inhibits the resin polymerization process (5). The most straightforward and practical approach to counteract the reduction in bond strength after bleaching is to wait for a period of time ranging from 24 h to 3 weeks before placing the restoration (6). However, some studies have shown that applying antioxidants to bleached enamel and dentin before bonding can positively affect bonding (7). It has been suggested that the use of antioxidants after teeth bleaching eliminates the need to wait for the restoration of teeth (8). In these studies, 10% sodium ascorbate was generally preferred (9, 10). Many studies have reported that 10 minutes may be sufficient for the application of sodium ascorbate to bleached tooth surfaces (10). Apart from these characteristics, it has been reported that the application of acetone-based bonding agents, complete removal of superficial enamel, and the use of drying agents such as alcohol on the tooth surface can have positive effects on bonding (11).

The moist bonding technique with ethyl alcohol is a novel approach to dentin bonding with adhesives (12). It has been reported that using ethyl alcohol instead of water in the moist binding technique provides a stronger binding when introducing hydrophobic monomers into the demineralized collagen matrix (13). According to the literature, pretreatment of bleached enamel with 70% alcohol can reduce residual water and oxygen and increase the bond strength of composite resin to the enamel (14). The literature review did not yield any studies on the effect of alcohol application on dentin-composite resin bond strength after bleaching.

Cervical root resorption is another negative effect of teeth whitening that have undergone endodontic treatment. The use of calcium hydroxide as a temporary dressing material in the pulp chamber has been demonstrated to prevent cervical root resorption (15). Although the mechanism of action of calcium hydroxide is unknown, it has been suggested that ion diffusion through the root canal inhibits osteoclastic activity by increasing the pH in dental tissues. The impact of

calcium hydroxide application on the bonding strength of composite resins to bleached dentin has not yet been demonstrated (16).

The aim of this in vitro study was to investigate the effects of sodium ascorbate, alcohol, and calcium hydroxide as buffering agents on the composite resin-dentin bond strength of non-vital bleached teeth.

## Materials and Methods

Ethics committee approval was received for this study from the Scientific Ethics Committee of the Dicle University, Faculty of Dentistry, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2019/11-9.

Eighty human upper central incisors with complete root development, without caries, cracks, or fractures on the root surface, and without internal or external root resorption were used for this study with the approval of the ethics committee. The teeth were stored in distilled water at room temperature until they were used.

An endodontic access cavity was prepared on the palatal surface of the teeth using an aerator (W&H Alegria, Bürmoos, Austria) and a diamond round bur (Kerr, Bioggio, Switzerland). The root canal was then entered 2-3 mm deep with a Gates-Glidden bur, and any remaining pulpal tissue was removed. The teeth were sectioned 2-3 mm below the enamel-cementum boundary using a round-tipped cylinder bur (Kerr, Bioggio, Switzerland), and the root section was then removed. The specimens were embedded in cold acrylic (S.C. Imicryl, Konya, Türkiye) in molds prepared with a 1.5x1.5 cm silicone impression (Zhermack, Badia, Polesina, Italy), leaving the palatal surfaces exposed to form a block. Glass ionomer cement (3M Espe, Seefeld, Germany) in powder-liquid form was placed on the pulp chamber floor as a base material in 80 upper central incisors. The teeth were left for 45 min to allow the base material to harden completely. The teeth were randomly divided into four groups, each containing 20 teeth. One group served as the control group, and the other three served as the experimental groups. All groups, including the control group, underwent non-vital bleaching. The study groups are shown in Table 1 (n:20)

**Table 1.** The study groups

	Bleaching	Groups	Number of teeth
1	Sodium perborate	Sodium ascorbate	20
2	Sodium perborate		20
3	Sodium perborate	Calcium hydroxide	20
4	Sodium perborate		20

The specimens were treated with sodium perborate (Merck KGaA, Darmstadt, Germany) using the walking bleach technique and mixed with water according to the manufacturer's instructions. A sterile cotton ball was inserted into the cavity and sealed with a temporary filling material (i-dental, Siauliai, Lithuania). The specimens were left for one week. Subsequently, the bleaching material in the pulp chamber was removed with water, and the specimens were air-dried. Finally, the specimens were placed in an oven at 37°C for one week.

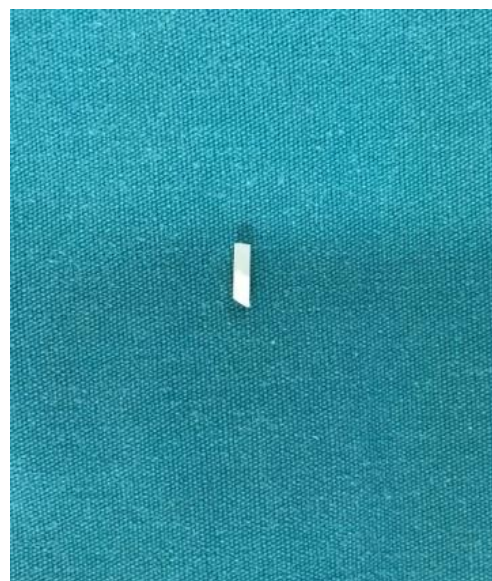
Group 1 samples were treated with a 10% sodium ascorbate (Smart Kimya, İzmir, Turkey) solution for 10 min at the entrance cavities. Group 2, 70% ethyl alcohol was applied to the entrance cavities using impregnated cotton pellets. Group 3 samples had calcium hydroxide (Pyrax Polymars, Uttarakhand, India) mixed with distilled water and applied to the entrance cavities according to the manufacturer's instructions. The teeth were then covered with a temporary filling material and left for one week.

A bonding agent (Dentsply Sirona, Charlotte, NC, USA) was applied to all teeth in the study groups, followed by permanent restoration of the cavities using the incremental technique with composite resin filling (Kuraray Noritake Dental, Okayama, Japan). Polymerization was performed using a light-curing device (Woodpecker, Guilin, China).

The sections containing both dentin and composite were obtained from the teeth embedded in an acrylic block using a 1 × 1 mm low-speed precision cutting device (Minitom, Struers, Copenhagen, Denmark) under water cooling (Fig. 1). The surface area of each section was 1 mm<sup>2</sup>, and they were shaped like 'I' bars (Fig. 2).

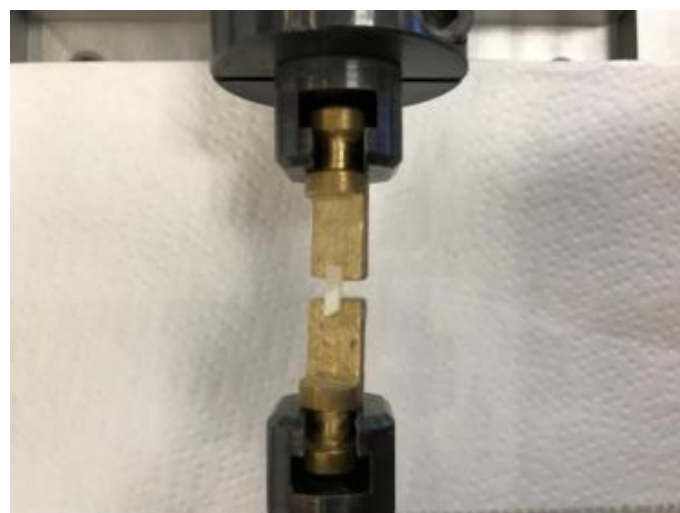


**Figure 1.** Obtaining cross-sections from teeth embedded in an acrylic block with a precision cutting device.



**Figure 2.** Composite resin-dentin rod example.

Composite resin-dentin rods were prepared and attached to microtensile holders using cyanoacrylate on both sides. A microtensile device (SD Mechatronik, Westerham, Germany) was used to measure the tensile force at a speed of 1 mm/min until the specimen fractured. The loading tip of the microtensile device was connected to the computer program and set to 1 mm/min (Fig. 3).



**Figure 3.** Composite resin-dentin rod bonded to the microtensile device with cyanoacrylate.

The fracture force of the samples was measured in Newtons (N) and then converted to megapascals using the formula provided;

MPa = Force (Newton) / Area (mm<sup>2</sup>)

## Results

### Statistical Analysis

SPSS software (version 22.0; IBM Corp., Armonk, NY, USA) was used for statistical analysis. To investigate the compatibility of the variables with a normal distribution due to the number of units, the Shapiro-Wilk test was utilized. The significance level of 0.05 was used during the interpretation of the results, and if  $p < 0.05$ , it was concluded that the variables did not fit the normal distribution.

The Kruskal-Wallis H-test was used to examine the differences between the groups because the variables did not follow a normal distribution. If significant differences were found in the Kruskal-Wallis H-test, the groups with differences were determined using the Post-Hoc Multiple Comparison test.

There was a statistically significant difference between the groups in terms of bond strength values ( $p < 0.05$ ). The bond strength value of the sodium ascorbate group was significantly higher than those of the calcium hydroxide and control groups ( $p < 0.05$ ).

No statistically significant difference was found between the bond strength values of the sodium ascorbate and alcohol groups ( $p > 0.05$ ). No statistically significant difference was found between the bond strength values of the alcohol and calcium hydroxide groups ( $p > 0.05$ ). No statistically significant difference was found between the bond strength values of the alcohol and control groups ( $p > 0.05$ ). No statistically significant difference was found between the bond strength values of the calcium hydroxide and control groups ( $p > 0.05$ ).

Table 2 and Figure 4 present the bond strength values obtained for the samples.

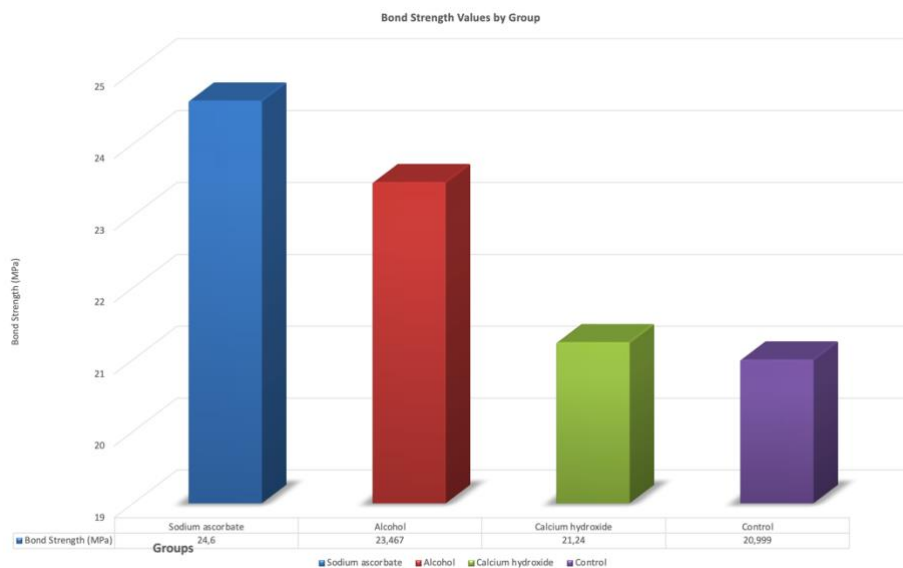


Figure 4. Differences between groups in terms of bond strength values.

Table 2. Analysis result regarding differences between groups in terms of bond strength values.

	Group	Group						Kruskal-Wallis H		
		Average	Median	Lowest	Highest	SD	Rank average	H	p	
Bond Strength	Sodium ascorbate	20	24.6	24.75	20	31.33	3.291	55.43	15.465	0.001
	Alcohol	20	23.467	22.58	17.33	31.5	4.272	44.33		
	Calcium hydroxide	20	21.24	20.915	18.5	24.67	1.988	32.55		
	Control	20	20.999	20.165	17.83	25.17	2.361	29.7		
	Total	80	22.577	21.83	17.33	31.5	3.406		4-1 3-1	

## Discussion

Several complications of non-vital bleaching have been reported, ranging from postoperative sensitivity and pulp irritation to changes in tooth structure and microleakage in existing restorations (17). Other important complications after bleaching include decreased bond strength of the composite resin with enamel-dentin, discoloration and cervical root resorption (18, 19).

Numerous studies have reported that the decrease in bond strength of composite resins after bleaching may be due to the presence of residual free radicals formed as a result of the breakdown of hydrogen peroxide (20). Residual oxygen has been reported to inhibit resin polymerization and increase the porosity of the resin (21). It has been reported that changes in tooth structure, such as porosity and calcium loss, can weaken bond strength (22). Therefore, researchers have suggested maintaining the restoration for a week after bleaching to prevent a decrease in bond strength value (23). In our *in vitro* study, the teeth were kept in an oven at 37°C for one week to account for this.

In addition to delaying restoration construction, recommended methods to increase bond strength values include the use of antioxidant agents and pretreatment of the tooth surface with alcohol (24). Antioxidants and pretreatment with 70% alcohol neutralize residual free radicals, reversing the reduced bond strength between the composite resin and enamel-dentin (25). In our study, sodium ascorbate and alcohol were applied to the dentin surface after non-vital bleaching treatment to prevent the negative effects of residual oxygen and to increase the composite resin-dentin bond strength.

The use of sodium ascorbate, an antioxidant agent with low toxicity and a neutral pH 7 (approximately), is suitable for dental structures. Studies have shown that the application of a 10% sodium ascorbate antioxidant solution after bleaching can increase the bond strength between the composite resin and dentin (26, 27). Souza-Gabriel et al. reported that the bond strength of teeth treated with sodium ascorbate was comparable to that of teeth restored after waiting for 10 days after bleaching (28). Elawysa et al. found that the bond strength between composite resin and dentin increased with the use of sodium ascorbate, without the need for a waiting period after bleaching (29).

Rodriguez-Barrague et al. conducted a systematic review and meta-analysis of 24 studies to investigate the effect of antioxidants on the bond strength of adhesives to enamel after non-vital bleaching. The authors reported that the use of antioxidants may be beneficial when performing resin-based restorations immediately after bleaching procedures (8).

Trindade et al. demonstrated that the bond strength between composite resin and intracoronal dentin can be increased by the use of sodium ascorbate, regardless of its concentration (30). In their *in-vitro* study, Alencar et al. investigated the effect of various factors on enamel bond strength after bleaching with 35% hydrogen

peroxide. The study concluded that waiting 7 days after bleaching before performing a restoration significantly improved bond strength. Additionally, sodium ascorbate application increased bond strength, even when restoration was performed without a waiting period after bleaching (31). Soeno et al. reported that ascorbic acid increased the adhesion of the bonding agent to dentin by acting as an antioxidant agent (32). In this study, we found that applying 10% sodium ascorbate as an antioxidant agent increased the bond strength of the composite resin to dentin. This increase was statistically significant and consistent with the findings of Trindade et al. (30), Alencar et al. (31), and Soeno et al. (32).

Pauletto et al. investigated whether sodium ascorbate could restore the bonding strength of composite resin restorations to sodium hypochlorite (NaOCl)-treated dentin. This comprehensive review demonstrated that sodium ascorbate effectively restored the bond strength of composite resin restorations to NaOCl-treated dentin (33).

The study conducted by Zavaki et al. compared the effectiveness of two common methods, namely 10% sodium ascorbate and Er:YAG laser irradiation, in increasing the microtensile bond strength of composite resin to whitened enamel. The result of the study shows that the microtensile bond strength of composite resin to bleached enamel can be increased with 10% sodium ascorbate and Er:YAG laser irradiation (34).

Gündoğdu et al. reported that natural plant-based antioxidants could serve as an alternative to synthetic sodium ascorbate. This could enable the restoration of bleached tooth tissues with resin-containing materials without any waiting period (35). Ilday et al. found that the use of various antioxidants on the bleached enamel surface before restoration procedures could effectively neutralize the negative effects of bleaching materials and increase bond strength (36).

Kum et al. suggested that pre-treating bleached enamel with alcohol can reduce residual water and oxygen, thereby increasing the bond strength of the composite resin to the enamel (14). It has been reported that applying alcohol on bleached enamel increased bond strength, but values did not return to the levels of the unbleached group. It is suggested that an alcohol-based binding agent may have minimized the inhibitory effects of the bleaching process through the interaction of alcohol with residual oxygen (37). Although the effect of alcohol on composite resin-dentin bond strength was higher in our study than in the control group, this difference was not statistically significant.

It has been reported that filling the pulp chamber with calcium hydroxide can prevent osteoclastic activity by increasing the pH (38). Feiz et al. reported a decrease in bond strength values of calcium-treated teeth after bleaching compared to non-whitened teeth (16). Demarco et al. showed that temporary dressing of the pulp chamber with calcium hydroxide had no effect on microleakage and did not affect the bonding capacity of the bonding agent after bleaching (39). In our study, calcium hydroxide application did not negatively affect the composite resin-dentin bond strength.

## Conclusion

The application of sodium ascorbate after non-vital bleaching may improve the bond strength of composite resin to dentin.

Our study is one of the few that evaluated the effects of alcohol application on the bond strength of composite resin to dentin after non-vital bleaching. Therefore, we believe that this practice should be supported by the results of more scientific studies to evaluate the effects of alcohol administration in more detail.

## Disclosures

**Ethical Approval:** Ethics committee approval was received for this study from the Scientific Ethics Committee of the Dicle University, Faculty of Dentistry, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2019/11-9.

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**Conflict of Interest:** No potential conflict of interest relevant to this article was reported.

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