

Influence of post-bleaching time intervals on dentin bond strength

Influência de tempos de espera pós-clareamento na resistência adesiva da dentina

Erica Cappelletto Nogueira Teixeira*

Cecilia Pedroso Turssi**

Anderson Takeo Hara**

Mônica Campos Serra***

ABSTRACT: It has been reported that bond strength of resin to tooth structure can be reduced when the bonding procedure is carried out immediately after the bleaching treatment. This study evaluated the effect of bleaching of non-vital teeth bleaching on the shear bond strength (SBS) of composite resin/bovine dentin interface and the influence of delaying the bonding procedures for different time intervals following internal bleaching. According to a randomized block design, composite resin cylinders (Z100/Single Bond - 3M) were bonded to the flattened dentin surface of two hundred and fifty-six teeth which had previously been subjected to four different treatments: SPH - sodium perborate + 30% hydrogen peroxide; SPW - sodium perborate + distilled water; CP - 37% carbamide peroxide; and CON - distilled water (control), each one followed by storage in artificial saliva for 0 (baseline), 7, 14, and 21 days after bleaching (n = 16). The bleaching agents in the pulp chambers were replaced every 7 days, over 4 weeks. The SBS test of the blocks was done using a universal testing machine. The ANOVA showed that there was no significant interaction between time and bleaching agents, and that the factor time was not statistically significant (p > 0.05). For the factor bleaching treatment, the Student's *t*-test showed that [CON = CP] > [SPW = SPH]. The bleaching of non-vital teeth affected the resin/dentin SBS values when sodium perborate mixed with 30% hydrogen peroxide or water was used, independently of the elapsed time following the bleaching treatment.

DESCRIPTORS: Tooth bleaching; Dentin-bonding agents.

RESUMO: Tem-se sugerido que a qualidade da adesão resina composta-dentina pode ser prejudicada quando restaurações são confeccionadas imediatamente após o tratamento clareador. Este estudo avaliou o efeito da postergação do procedimento adesivo após o clareamento interno realizado com diferentes agentes na resistência ao cisalhamento da interface compósito/dentina. De acordo com um delineamento aleatório em blocos completos, cilindros de resina composta (Z100/Single Bond - 3M) foram confeccionados em duzentos e cinquenta e seis fragmentos dentinários bovinos planejados, os quais foram previamente submetidos a 4 tratamentos: PSH - perborato de sódio + peróxido de hidrogênio a 30%; PSA - perborato de sódio + água destilada; PC - peróxido de carbamida a 37% e CON - água destilada (controle), sendo estes seguidos pelo armazenamento em saliva artificial por 0, 7, 14 e 21 dias após o clareamento (n = 16). Os agentes clareadores inseridos na câmara pulpar foram substituídos a cada 7 dias, durante 4 semanas. O teste de resistência ao cisalhamento foi realizado em máquina de ensaios universal. ANOVA mostrou que a interação entre os tempos e os agentes clareadores não foi significativa (p > 0,05). Para o fator tratamento clareador, o teste *t* de Student revelou que [PC = CON] > [PSA = PSH]. Independentemente do tempo decorrido após o clareamento, os valores de resistência adesiva entre resina e dentina foram reduzidos quando se utilizou perborato de sódio associado ao peróxido de hidrogênio ou à água.

DESCRIÇÕES: Clareamento de dente; Adesivos dentinários.

INTRODUCTION

Esthetic treatment is currently receiving increased interest, but since the 1800s tooth bleaching has been a part of dentistry^{3,23}. Tooth bleaching can avoid more costly and invasive dental treatment, preserving tooth structure^{3,11}.

In an endodontically treated tooth, the intracoronary bleaching technique called walking bleach has proved popular. This technique is performed by

using a paste of sodium perborate mixed with either hydrogen peroxide or water, which is placed in the pulp chamber and sealed for several days^{11,12,14}. Once the bleaching process is complete, the pulp chamber must be restored, and the replacement of esthetic restorations may be necessary, in order to match the color of the bleached tooth. In general, composite resins associated with a dentin bonding

* MSc; **Doctorate Students – Department of Restorative Dentistry, School of Dentistry of Piracicaba, Campinas State University.

*** PhD, Associate Professor, Department of Restorative Dentistry, School of Dentistry of Ribeirão Preto, University of São Paulo.

system are used⁸.

Although tooth bleaching presents satisfactory esthetic results, some investigations have shown a deleterious effect of peroxide bleaching on the adhesion of composite resins to tooth structure^{6,8,15,20}. That has become a concern in esthetic dentistry.

It has been shown that exposure to hydrogen peroxide causes a substantial reduction in the adhesiveness of composite resin to the enamel¹⁶⁻¹⁸. However, the influence of some bleaching agents, like sodium perborate and 37% carbamide peroxide, placed in the pulp chamber for bleaching on dentin prior to bonding procedures, is unknown.

In the present study, an experimental bleaching procedure was used to analyze the duration of these possible effects after bleaching of non-vital teeth. Thus, this *in vitro* study was designed to assess the effect of bleaching agents on composite resin/dentin shear bond strength at different post-bleaching time intervals.

MATERIALS AND METHODS

Experimental design

The factors under study were bleaching treatment: sodium perborate + 30% hydrogen peroxide (SPH); sodium perborate + distilled water (SPW); 37% carbamide peroxide (CP); and control (CON-distilled water) and time intervals: 0 (baseline), 7, 14 and 21 days after bleaching. The experimental units were 256 bovine incisors (n = 16), divided into 16 groups (4 bleaching treatments *versus* 4 time intervals). This study used a randomized complete block design, with 16 blocks. Within each block, the order used to apply the different bleaching treatments was randomly determined. The response variable was shear bond strength (SBS) in MPa.

Tooth preparation

Endodontic access cavities were prepared in 256 bovine incisor teeth, using a conical end diamond point cylinder (n° 4124 - KG Sorensen, São Paulo, SP, Brazil). The pulp was debrided with a dental explorer. The roots were sectioned 2 mm below the cemento-enamel junction with a double-face diamond disk (KG Sorensen, São Paulo, SP, Brazil) and sealed with composite resin (Z100, 3M, St. Paul, MN, USA).

Bleaching procedure

A mixture of 2 g of sodium perborate (Farmavip Ltda., Piracicaba, Brazil) with 1 ml of 30% hydrogen peroxide solution (Farmavip Ltda., Piraci-

caba, SP, Brazil) was used as the bleaching agent for the SPH group, and, in the same ratio, 2:1 (g/ml), sodium perborate and distilled water for the SPW group. These pastes were prepared on a glass slab using a metal spatula for a 30-second period. A commercially available 37% carbamide peroxide gel (Whiteness, FGM Ltda., Joinville, SC, Brazil) was used as the bleaching agent for the CP group, and a cotton pellet embedded in distilled water for the control group (CON).

The bleaching agents or the cotton pellets were placed in the pulp chambers and sealed with Cavit (3M/ESPE Dental Products, St. Paul, MN, USA). These agents were replaced with fresh preparations every 7 days, according to the walking bleach technique. The pulp chamber was washed with water and dried with compressed air. This procedure was repeated for 4 weeks until the bleaching treatment was concluded. Throughout the entire experimental period, the teeth were kept in artificial saliva^{2,13}.

Bonding procedure and shear bond test

For the shear bond test, a piece of the central area of the facial crown of each tooth (5 mm high and 5 mm wide) was placed in a 3/4 inch diameter PVC ring (Tigre Corp., Joinville, Brazil). These fragments were embedded in self-curing polyester resin (Cromex, Piracicaba, SP, Brazil) and flattened through wet grinding using 320, 400, 600-grit Al₂O₃ abrasive paper (Carborundum Abrasivos, Recife, PE, Brazil), in order to expose the dentin underneath the enamel. After polishing, the dentin surfaces were demarcated with a piece of vinyl tape (Vulcan Ltda., Irajá, Brazil), in which a 3 mm-diameter hole had been made.

The dentin was etched with 35% phosphoric acid (3M Co., St. Paul, MN, USA) for 15 s and rinsed with tap water for 15 s. Afterwards, the dentin was slightly air-dried for 5 s and two consecutive adhesive coats (Single Bond, 3M Co., St. Paul, MN, USA) were applied using a saturated brush tip (Denbur Inc., Westmont, USA), air-dried for 5 seconds and light-cured for 10 s (Optlux 401, Demetron, Kerr Corp., Danbury, CT, USA).

A 3 mm-diameter teflon ring mold (5 mm high) was placed against the fragment to receive the composite resin (Z100, 3M Co., St. Paul, MN, USA). The filling material was inserted in two increments (2.5 mm high), both were light-cured (Optlux 401, Demetron, Kerr Corp., Danbury, CT, USA) for 40 s. Specimens deviating from the standard bonding surface preparation protocol (i.e. excessively

ground) were excluded prior to testing.

Each specimen was mounted in a custom-made jig and positioned in an Instron testing machine (4411, Instron Corp., Canton, MA, USA). A steel knife-edge was placed parallel to the specimen surface so that the shear force applied the load directly to the bond interface, using a cross-head speed of 0.5 mm/min. The SBS was measured in MPa.

Statistical analysis

Data were subjected to a two-way analysis of variance (ANOVA) and the Student's *t*-test at 5% level of significance. The SAS (6.12) software (SAS Institute Inc., Cary, NC, USA) was used for the statistical analysis.

RESULTS

The two-way ANOVA showed that there was no interaction between time and bleaching treatment ($p_{\text{value}} = 0.90$). There were statistically significant differences between the bleaching treatments ($p_{\text{value}} = 0.001$) (Table 1), but not between the time intervals ($p_{\text{value}} = 0.84$) (Table 2). Student's *t*-test ($p \leq 0.05$) revealed lower SBS mean values for the SPH and SPW groups in comparison to the CON and CP values.

DISCUSSION

Since the walking bleach technique was proposed by Spasser¹⁴, some modifications have been described in literature^{5,23}. The use of sodium perborate mixed with hydrogen peroxide demonstrated successful results, as well as its combination with water¹². The use of 10% carbamide peroxide was also suggested, in a modified walking bleach technique called inside/outside bleaching⁴. However, it has been shown that 10% carbamide peroxide was

less effective than 30% hydrogen peroxide mixed with sodium perborate⁷. Therefore, 37% carbamide peroxide agent, a more concentrated gel, was used in this study.

All those bleaching agents have hydrogen peroxide as the active substance. The mechanism of action of these agents consists of a strong oxidizing reaction that removes stain within the enamel and dentin, releasing free oxygen radicals^{3,23,24}. Some investigations showed side effects of the bleaching reactions on the adhesion of light-cured resins to enamel^{16,17,18} which might be related to the presence of residual hydrogen peroxide.

Although prolonged *in vitro* water exposure reversed the deleterious effect of residual bleaching peroxides on the SBS of composite resin to enamel²², this method was not effective for a rapid neutralization of the hydrogen peroxide⁹. The use of an enzyme called catalase was also suggested⁹. However, the effects of this substance on the restorative procedure are unknown. The delay in the subsequent restorative procedures has been considered a reasonable approach to improve the adhesion between the resin and tooth interface³. Therefore, in this study, the shear bond strength was evaluated immediately, 7, 14 and 21 days after an experimental bleaching procedure was performed following to clinical conditions.

The present study showed lower SBS values for the composite resin to the dentin surface in the SPW and SPH group. This reduction was independent of the time elapsed between the end of the bleaching procedure and the placement of the composite resin. The delay in bonding did not result in higher SBS values on resin/dentin interface. Probably, the hydrogen peroxide elimination in the dentin tubules was not enough to modify this result. The lower SBS values may have been

TABLE 1 - Means and standard deviations (SD) of shear bond strength test values (in MPa) according to the experimental groups.

Groups	CON	n	CP	n	SPW	n	SPH	n
Means (SD)	6.55 (3.18) ^a	62	6.68 (3.24) ^a	61	5.33 (3.17) ^b	61	4.79 (2.76) ^b	59

Statistical differences are expressed by different letters ($p < 0.05$). SPH: sodium perborate + 30% hydrogen peroxide; SPW: sodium perborate + distilled water; CP: 37% carbamide peroxide; CON: control (distilled water).

TABLE 2 - Means and standard deviations (SD) of shear bond strength test values (in MPa) according to the time intervals after bleaching.

Time	Baseline	n	7 days	n	14 days	n	21 days	n
Means (SD)	5.98 (1.17) ^a	63	5.91 (1.35) ^a	62	5.93 (0.77) ^a	58	5.53 (0.72) ^a	60

No statistical differences are expressed by same letters ($p > 0.05$).

caused by significant structural changes and a permanent alteration could have occurred to this substrate.

Previous reports hypothesize that changes in the dentin may interfere with the formation of bonding and could be responsible for the decrease of adhesion^{19,21}. In addition, hydrogen peroxide in higher concentrations may cause an alteration in the organic and inorganic components of the dentin¹¹.

Rotstein *et al.*¹⁰ (1996), by means of a histochemical analysis, observed a decrease in the Ca/P ratio after the bleaching procedure, which was more significant in the cementum and dentin than in the enamel. In a recent study it was also argued that the intracoronal bleaching with hydrogen peroxide and sodium perborate in combination or alone weakened the dentin¹.

The main factor in the results was the bleaching treatment. The CP group showed results similar to the CON group, probably due to the action mechanism that offers a slower release of hydrogen peroxide^{3,24}. Although the sodium perborate associated with water is also said to have a slow release of hydrogen peroxide²⁴, this group differed from the control. Another factor that may have influenced our results was the cleaning of the pulp chamber after the bleaching treatment. It was more difficult

to wash the sodium perborate than the carbamide peroxide, which is soluble in water. In the SPH group, a lower SBS value was noticed, possibly because of the higher amount of hydrogen peroxide and the swift action mechanism²⁴. In this study, the adverse effects observed on the outer dentin were presumably a result of bleaching agent diffusion via the dentinal tubules.

Under the experimental conditions adopted in the present study, it was possible to conclude that sodium perborate associated with water or hydrogen peroxide caused lower SBS values of composite resin to the dentin surface. The 37% carbamide peroxide did not affect the SBS values. This investigation suggests that the shear bond strength of composite resin on bleached dentin surface may be acceptable, when the carbamide peroxide is used as the internal bleaching agent, independently of the post-bleaching intervals.

CONCLUSION

In this study, the bleaching procedure performed with 37% carbamide peroxide did not affect the resin/dentin SBS values. However, the SBS values were affected by the use of sodium perborate mixed with 30% hydrogen peroxide or water, independently of the elapsed time following the bleaching treatment.

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