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Effect of Bleaching Protocols with 38% Hydrogen Peroxide and Post-Bleaching Times on Dentin Bond Strength

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This study assessed the effect of bleaching protocols with 38% hydrogen peroxide (HP) and post-bleaching times on shear bond strength of a composite resin to dentin. One-hundred slabs of intracoronary dentin were included and randomly assigned into 2 groups according to the bleaching protocol: HP (2 applications of 10 min each) and HP activated by LED laser (2 applications of 10 min each/45 s of light activation). Groups were subdivided according to the post-bleaching time (n=10): 1 day, 3 days, 7 days, 10 days and 14 days. The control group was unbleached and restored (n=10). The specimens were restored with Single Bond adhesive system/Filtek Z250 resin using a polytetrafluorethylene matrix and were submitted to the shear bond strength testa after 24 h,. Data were analyzed by ANOVA and Tukey's test (α=0.05). Unbleached group (0.283 ± 0.134) had the highest bond strength and was statistically similar ($p>0.05$) to HP/10 days (0.278 ± 0.064), HP + LED laser/10 days (0.280 ± 0.078), HP/14 days (0.281 ± 0.104), HP + LED laser/14 days (0.277 ± 0.093). Lower bond strength were verified in HP/1 day (0.082 ± 0.012), HP/3 days (0.079 ± 0.013), HP + LED laser/1 day (0.073 ± 0.018) and HP + LED laser/3 days (0.080 ± 0.015), which were statistically similar ($p>0.05$). HP/7 days (0.184 ± 0.154) and HP + LED laser/7 days (0.169 ± 0.102) had intermediate values ($p<0.05$). The restorative procedure of intracoronary dentin bleached with 38% HP with or without the use of light source should be performed after at least 10 days after the bleaching treatment.

Key Words: shear bond strength, hydrogen peroxide, bleaching, post-time bleaching.

INTRODUCTION

Tooth bleaching is a procedure in which chemical products catalyzed or not by heat or light sources promote chromatic alterations in the dental tissues. Bleaching agents act by an oxidation-reduction reaction with the darkened substrate (1-3). When the whitening agent is placed into the pulp chamber, reactive oxygen is released from the degradation of the bleaching agent, the colored substance is chemically reduced and transformed into a colorless material, producing the whitening effect (3).

Due to its reactive properties, hydrogen peroxide (HP) is the main active chemical component of most agents used in tooth bleaching therapies. HP can be used in its pure form or as the final product of the degradation of other bleaching substances, such as sodium perborate and carbamide peroxide (2).

Light sources are used to catalyze the bleaching process by intensifying the oxi-reduction reaction and accelerating the release of hydroxyl (OH-) radicals (4,5). Light-emitting diode (LED)-laser system is a cost-effective alternative to other light sources, with less energy needed to generate light (6). The LED-laser is a cold light originated from semiconductors and provides less heat generation (4,6). Additionally, it has been shown to be more efficient compared to halogen lamps (5).

The clinical performance of resin-based composite restorations after the bleaching procedure can be influenced by possible alterations from presence of bleaching agents in the dental structure (7-11). Free

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radicals from oxygen that remain in the dental tissues can inhibit the light activation of resin materials with subsequent reduction in bond strength of resin-based composite restorations (8,11).

A waiting time between the bleaching procedure and restorative treatment should be allowed to eliminate the residual oxygen from the dental substrate to return to condition that leads to normal bond strengths (7,9,10,12). Nevertheless, the appropriate post-bleaching time interval following the bleaching treatment is not well established. Therefore, this *in vitro* study evaluated the influence of delaying the restorative procedure for different time intervals following bleaching with 38% HP at different protocols on shear bond strength of a resin composite restoration to intracoronary dentin.

MATERIAL AND METHODS

The study protocol was reviewed and approved by the University Ethics' Committee (Protocol number 084/2010).

Experimental Design

The factors under study were dental bleaching at 2 levels: 38% hydrogen peroxide (Opalescence Xtra Boost; Ultradent Products Inc., UT, USA) and 38% hydrogen peroxide + activation with LED-laser (Brightness; Kondortech, São Carlos, SP, Brazil), and post-bleaching time intervals to restoration at 5 levels: immediate, 3, 7, 10 and 14 days. One-hundred intracoronary specimens were randomly assigned into these 10 experimental groups (n=10). Ten additional slabs were part of a control group that was not subjected to bleaching and was restored. The response variable was shear bond strength to the intracoronary dentin.

Dentin Sample Preparation

Fifty-five human superior canines stored in 0.1% thymol solution at 4ºC were washed in running water for 24 h to eliminate thymol residues. Teeth were examined under a ×20 magnifier (Leica Microsystems, Wetzlar, Germany) to discard those with structural defects as fissures and defective grooves. Roots were sectioned 2 mm below the cementoenamel junction. Crowns were fixed in wax, bisected longitudinally in a mesiodistal direction using a double-faced diamond disk (KG Sorensen, Barueri, SP, Brazil) and mounted in a low-speed handpiece (Dabi Atlante, Ribeirão Preto, SP, Brazil). Each crown half was sectioned in the incisal, mesial, distal and cervical faces to obtain 5-mm wide x 5-mm high (25 mm^2) slabs, totalizing 110 slabs.

The fragments were embedded in self-polymerized acrylic resin (Jet; Clássico Produtos Odontológicos Ltda., São Paulo, SP, Brazil) surrounded by a polyvinyl chloride (PVC) cylinder (1.5-cm diameter and 1.5-cm high) with the intracoronary dentin faced up. After resin polymerization, the PVC cylinder was removed and the dentin surface was ground with 280- and 400-grit silicon carbide (SiC) paper (Norton, Lorena, SP, Brazil) under water cooling to obtain flat dentin surface. Complementary grinding was accomplished with 1200-grit SiC paper for 1 min to produce a standardized smear layer. The specimens were irrigated with 10 mL of 1% sodium hypochlorite to simulate the irrigation protocol performed during biomechanical preparation of the root canals.

Bleaching Treatment

The specimens were randomly assigned to 2 groups, according to the surface treatment: bleached with 38% HP (Opalescence Xtra Boost) and bleached with 38% hydrogen peroxide activated by the LED-laser system (Brightness; Kondortech).

The red activator was mixed with the colorless bleaching gel at the moment of use, according to the manufacturer´s instructions. The bleaching gel was applied to the dentin surface for 10 min. In the group activated by LED-laser, the light was applied for 45 s. The bleaching protocol was repeated 3 times, with a 5-min interval between them. The gel was aspirated, and the surfaces were washed with distilled water and dried with oil-free compressed air.

Shear Bond Strength Test

The specimens were subdivided according to the post-bleaching time intervals previously the restoration (n=10): immediately, 3 days, 7 days, 10 days and 14 days after the bleaching procedure. The bleached specimens were kept in artificial saliva at 37°C until restoration.

The dentin surfaces were etched with 37% phosphoric acid (3M ESPE, St. Paul, MN, USA) for 15 s, washed with a water spray and dried with absorbent points. Single Bond adhesive system (3M ESPE) was applied according to the manufacturer's instructions and light activated for 10 s using a halogen light-curing unit (Dabi Atlante).

Dentin surface were restored using a split Teflon matrix (3 x 3 x 4 mm) stabilized with addition silicone impression material. The specimens received the application of the Filtek Z250 resin (3M ESPE), and the material was polymerized for 20 s (Dabi Atlante). Sequentially, the silicone contention was removed and the matrix was carefully opened, leaving a resin rectangle adhered to the dentin surface. A complementary polymerization for 20 s was accomplished to ensure that specimen was adequately polymerized. The specimens were kept in artificial saliva at 37°C for 24 h.

Specimens were subjected to shear bond strength test in an universal testing machine (Instron 4444; Instron Corporation, Canton, MA, USA) at a 0.5 mm/min crosshead speed and a 2 kN load cell until displacement of the restoration. Shear bond strength values were registered in kN.

The resin/dentin interface of the fractured specimens was analyzed under a stereoscopic microscope at ×40 magnification (Leica Microsystems), and displayed as percent values. Failure was considered adhesive if it occurred at the dentin/adhesive interface, cohesive if it occurred within the material or the substrate, and mixed if it involved both the interface and the material.

Statistical Analysis

Shear bond strength data expressed as means and standard deviations were analyzed by ANOVA and Tukey-Kramer test for multiple comparisons at a 0.05 significance level (Instat Program; GraphPad Software, San Diego, CA, USA).

RESULTS

Shear bond strength means (in kN) and standard deviations of the of restorative material to dentin and failure types after test in the different experimental groups are presented in Table 1.

There was statistically significant differences (p=0.0065) among the bleaching protocols and among the post-bleaching times. The unbleached group (control) (0.283 ± 0.134) had the highest bond strength mean and was statistically similar (p>0.05) to groups: HP/10 days (0.278 ± 0.064), HP + LED laser/10 days (0.280 ± 0.078), HP/14 days (0.281 ± 0.104), HP + LED laser/14 days (0.277 ± 0.093) and statistically different (p<0.05) from the others.

Significantly lower bond strength values were verified in groups: HP/1 day (0.082 ± 0.012), HP/3 days (0.079 ± 0.013), HP + LED laser/1 day (0.073 ± 0.018) and HP + LED laser/3 days (0.080 ± 0.015), which were statistically similar (p>0.05). HP/7 days (0.184 ± 0.154) and HP + LED laser/7 days (0.169 ± 0.102) had intermediated values (p<0.05).

The analysis of failure type after the shear bond strength test demonstrated the predominance of mixed failure in the control group (unbleached). The specimens that received the bleaching treatment, regardless of the post-bleaching time interval, exhibited a predominance of adhesive failures. Cohesive failures were verified only unbleached specimens and those with post-bleaching time of 10 and 14 days (Table 1).

Table 1. Shear bond strength means (in kN) and standard deviations of the of restorative material to dentin and failure types after test in the different experimental groups.

Experimental groups	Bond strength (kN)	Failure mode (%)		
	Means ± SD	Adhesive	Cohesive	Mixed
Non-bleached teeth (control)	0.283 ± 0.134 a	40	10	50
HP/1 day	0.082 ± 0.012 b	70	0	30
HP/3 days	0.079 ± 0.013 b	80	0	20
HP/7 days	0.184 ± 0.154 ab	60	0	40
HP/10 days	0.278 ± 0.064 a	60	0	40
HP/14 days	0.281 ± 0.104 a	50	10	40
HP + LED-laser/1 days	0.073 ± 0.018 b	80	0	20
HP + LED-laser/3 days	0.080 ± 0.015 b	90	0	10
HP + LED-laser/7 days	0.169 ± 0.102 ab	40	0	60
HP + LED-laser/10 days	0.280 ± 0.078 a	40	10	50
HP + LED-laser/14 days	0.277 ± 0.093 a	60	0	40

Different letters indicate statistically significant difference (Tukey-Krammer test, p<0.05)..

DISCUSSION

High-concentrated HP is

one of the most used bleaching agents in non-vital teeth. Due to its low molecular weight, its degradation products (oxygen and perhydroxyl) are able to penetrate into tooth structure (10). However, temporary filling materials need to be replaced by composite resin restorations (13) and, thus, the post-bleaching time that needs to elapse before the restoration is important to be evaluated (12).

The bleaching agent used in this study (Opalescence Xtra Boost) contains carotene as light-absorbing agent and, although this is a chemically activated product, the manufacturer reports that some professionals prefer to activate the bleaching gel using a light source (11). The results of the present study, revealed that bleaching intracoronary dentin with 38% HP was similar to 38% HP activated by LED-laser system. This is probably due to the fact that LED light did not produce significant temperature rise on dentin (4,6) and, consequently, did not generate thermal adverse effects that could affect the bond strength of restorative material (5). Although LED-laser is a viable light system that does not heat tooth structure, it has been shown that its use does not increase the bleaching efficacy (14). Therefore, the outcomes of this study rejects the hypothesis of a correlation between LED-laser light activation and bond strength decrease in teeth undergoing internal bleaching.

Regarding post-bleaching time intervals, it was observed a decrease of shear bond strength of resin to dentin when the restoration was performed immediately, 3 days and 7 days after bleaching, regardless of the light activation. The decrease in bond strength is due to the properties of peroxide and their action on dental tissues. Because of its high oxidation potential, OH^- radicals act in intertubular and peritubular dentin breaking the polypeptide chains and collagen and hyaluronic acid, thereby, attacking the organic component of dentin (15). These morphological alterations increase dentin permeability (16,17) and reduce hardness (18), which may be intensified by a higher exposure of dentin to the bleaching agent. Additionally, HP degradation causes the release of water and free radicals from oxygen (9). The oxygen liberation can interfere in the penetration of resin into dentinal tubules, as well as to inhibit their polymerization (7,10).

The delay in performing the resin restoration (10 and 14 days), also regardless of light use, produced bond strength values similar of those achieved with the unbleached specimens (control). The interval of 10 and 14 days before the resin restoration nullifies the effect of residual oxygen in dentin tubules. A recent *in situ* (10) study demonstrated that 7 days after completion of the bleaching with 35% HP, the bond strength to dentin increased to values similar to those found in the unbleached group. According to Shinohara et al. (7) and Barbosa et al. (9), a 14-day interval is sufficient to place composite resin restorations in dentin after bleaching. However, no previous study evaluated the elapsed time following the bleaching treatment of 10 day.

In this study, it was verified the prevalence of the adhesive failure mode in all the bleached specimens, regardless of the protocol or post-bleaching times. This fact can be explained by the methodology used since the shear bond strength acts directly at the adhesive interface causing the separation of the restoration from dentin. Some cohesive failures were observed only in groups with higher bond strength (unbleached, and bleached and restored after 10 and 14 days).

Overall, this study leads to conclusion that the restorative procedure of intracoronary dentin bleached with 38% HP, with or without the use of light source, should be performed after at least 10 days of the bleaching treatment. The precise mechanism by which the bleaching agents act on dentin is not yet clearly established. Other bleaching agents and analytical methods should be tested in future studies to obtain more information about the impact of bleaching on dental tissues.

RESUMO

Este estudo avaliou o efeito de protocolos de clareamento com peróxido de hidrogênio 38% (PH) e tempos pós-clareamento na resistência ao cisalhamento de uma resina composta à dentina. Cem fragmentos de dentina intracoronária foram incluídos e distribuídos aleatoriamente em 2 grupos experimentais de acordo com o protocolo de clareamento: PH (2 aplicações de 10 min cada) e HP ativado por LED laser (2 aplicações de 10 min cada/45 s de ativação pela luz). Os grupos foram subdivididos de acordo com o tempo pós-clareamento (n=10): 1 dia, 3 dias, 7 dias, 10 dias e 14 dias. O grupo controle não foi clareado e apenas restaurado (n=10). Os espécimes foram restaurados com sistema adesivo Single Bond/resina Filtek Z250 usando matriz de teflon. Após 24 h, foram submetidos ao teste de cisalhamento. Os dados foram analisados por ANOVA e teste de Tukey (α=0,05). O grupo não clareado (0,283 ± 0,134) apresentou a maior resistência de união e foi estatisticamente semelhante ($p>0,05$) ao PH- 10 dias (0,278 ± 0,064), PH + LED laser/10 dias (0,280 ± 0,078), PH/14 dias (0,281 ± 0,104), PH + LED laser/14 dias (0,277 ± 0,093). Resistência de união inferior foram verificadas para PH/1 dia (0,082 ± 0,012), PH/3 dias (0,079 ± 0,013), PH + LED laser/1 dia (0,073 ± 0,018) e PH + LED laser/3 dias (0,080 ± 0,015), que foram estatisticamente semelhantes entre si ($p>0,05$). HP/7

dias (0,184 ± 0,154) e PH + LED laser/7 dias (0,169 ± 0,102) apresentaram valores intermediários (p<0,05). O procedimento restaurador da dentina intracoronária clareada com peróxido de hidrogênio 38%, com ou sem o uso de fonte de luz, deve ser realizado pelo menos após 10 dias do tratamento clareador.

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