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Effect of 10% sodium bicarbonate on bond strength of enamel and dentin after bleaching with 38% hydrogen peroxide

Efeito do bicarbonato de sódio a 10% na resistência de união do esmalte e dentina após clareamento com peróxido de hidrogênio a 38%

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Resumo

Introdução: Subprodutos da degradação do peróxido de hidrogênio liberados durante o clareamento dental influenciam a polimerização de sistemas adesivos e resinas compostas, levando à redução da resistência de união à estrutura dental. **Objetivo**: O objetivo deste trabalho foi avaliar o efeito do bicarbonato de sódio a 10% (BS), aplicado por diferentes períodos de tempo na resistência de união ao esmalte e dentina após o clareamento. **Material e método**: Blocos de esmalte e dentina de terceiros molares humanos foram separados em grupos (n=10): (1) controle: ausência de clareamento; (2) imediato: clareamento seguido por restauração imediata; (3) 14 dias: clareamento, restauração 14 dias após; (4) BS por 10 minutos: clareamento, gel de BS por 10 minutos, restauração imediata; (5) BS por 20 minutos: clareamento, gel de BS por 20 minutos, restauração imediata. Um gel de peróxido de hidrogênio a 38% (Opalescence Boost/Ultradent) foi utilizado. Após aplicação do sistema adesivo, cilindros de resina composta foram confeccionados na superfície dos substratos para avaliar a resistência por cisalhamento. **Resultado**: ANOVA e teste de Tukey mostraram valores médios significativamente mais elevados para o grupo "14 dias" e sem diferença significativa do grupo "controle". Médias de valores para os outros grupos foram intermediárias. Para dentina, o teste de Tukey revelou maiores médias de valores significativos para a resistência de união para o grupo "14 dias" quando comparado à aplicação do BS por 20 minutos. **Conclusão**: O gel de BS não foi capaz de reverter os baixos valores de resistência de união ao esmalte e dentina após o tratamento clareador.

Descritores: Clareamento dental; peróxido de hidrogênio; resistência ao cisalhamento; bicarbonato de sódio.

Abstract

Introduction: By-products of hydrogen peroxide degradation released during dental bleaching influence the polymerization of adhesive systems and composite resins, causing a reduction in shear bond strength to the tooth. **Objective**: the aim of this article was to evaluate the effect of 10% sodium bicarbonate (SB), applied for different lengths of time, on the shear bond strength to enamel and dentin after bleaching. **Material and method**: Enamel and dentin blocks were divided into groups (n=10): (1) control: no bleaching; (2) immediate: bleaching immediately followed by restoration; (3) 14-day: bleaching, restoration 14 days later; (4) SB for 10 minutes: bleaching, SB gel for 10 minutes, immediately followed by restoration; (5) SB for 20 minutes: bleaching, SB gel for 20 minutes, immediately followed by restoration. A 38% hydrogen peroxide gel (Opalescence Boost/Ultradent) was used. After application of the adhesive system, composite resin cylinders were mounted on the surface of the substrates in order to test shear bond strength. **Result**: ANOVA and Tukey tests showed significantly higher mean enamel bond strength values for the 14-day follow-up group and without significant differences for control group. Mean bond strength values obtained for the other groups were intermediate. When testing dentin, the Tukey test revealed a significantly higher mean bond strength value for the 14-day follow-up group when compared with application of SB for 20 minutes. **Conclusion**: SB gel applied was unable to reverse the low bond strength to enamel and dentin after bleaching treatment.

Descriptors: Tooth bleaching; hydrogen peroxide; shear strength; sodium bicarbonate.

INTRODUCTION

By-products of hydrogen peroxide degradation, namely free oxygen (O-) and hydroperoxyl (HO_2-) ions, released during dental bleaching influence the polymerization of adhesive systems and composite resins, causing a reduction in shear bond strength to the tooth[1-6]. In order to avoid negative effects caused by residual free radicals, postponing restorative procedures for 24 hours to three weeks after bleaching is recommended[2,6-10]. Unfortunately, patients may consider this length of time inconvenient, as they may desire their restorations to have a similar color as their teeth soon after undergoing bleaching treatment.

To decrease or eliminate this waiting time, reversal agents (sodium ascorbate, catalase and alpha-tocopherol) have been used soon after bleaching treatment and/or before the placement of adhesive restorations in order to eliminate the presence of remaining free radicals[1,4-6,11-17]. Antioxidant agents can act in various ways, among these the removal or reduction of oxygen locally, removal of reactive oxygen species, such as superoxide radical O^2- and hydrogen peroxide, or by stabilizing or removing singlet oxygen (O-)[18].

In a study evaluating the antioxidant activity of several substances for immediate reversal of the problems caused by bleaching, Garcia et al.[19] showed that sodium bicarbonate presented antioxidant properties similar to those of sodium ascorbate gel and ascorbic acid gel and solution.

The mechanism of action of sodium bicarbonate is based on its high pH (approximately 8.67), which can destabilize the peroxide molecule and result in its decomposition and inactivation[14]. Torres et al.[14] demonstrated that the treatment of bleached enamel with sodium bicarbonate did not increase shear bond strength between composite resin and teeth; however, in their research they used bovine teeth and did not evaluate dentin, which is the substrate that concentrates and retains most of the by-products of hydrogen peroxide degradation[20,21]. On the other hand, Tostes et al.[22] showed that application of 10% sodium bicarbonate solution for 5 min could be an alternative pre-restorative treatment for bleached enamel; however, dentin was not evaluated.

The potential antioxidant effect of sodium bicarbonate after bleaching treatment is unclear. In addition, there is no protocol for its use, in terms of application time. Therefore, the aim of this study was to evaluate the effect of 10% sodium bicarbonate gel applied for different lengths of time, on the shear bond strength of adhesive systems to enamel and dentin, after bleaching with 38% hydrogen peroxide. The null hypothesis was that there would be no antioxidant effect exerted by sodium bicarbonate on shear bond strength between adhesive systems and enamel and dentin after bleaching treatment with 38% hydrogen peroxide.

MATERIAL AND METHOD

This study was approved by the Ethics Committee (No. 2012/0190). Twenty-five extracted human impacted third molars were obtained from the Human Tooth Bank of São Leopoldo Mandic Dental School, Campinas/SP. The teeth were stored in 0.1% thymol solution for up to a maximum of six months. Fifty enamel blocks and 50 dentin blocks, measuring 4mm × 4mm × 3mm were obtained by means of cross-sectioning with a precision cutting saw (Isomet 1000, Buehler LTDA, Lake Bluff, Illinois, USA) using a high concentration cutting disc (Buehler LTDA, Lake Bluff, Illinois, USA), and separating the root portion from the crown. The teeth were then cut longitudinally and mesio-distally for dentin and enamel, respectively. The tooth blocks were embedded in polyethylene resin (Maxi Rubber Indústria Química LTDA, Diadema, SP, Brazil), leaving the external surfaces of the enamel and dentin exposed, or free of resin.

After 24 hours, the enamel blocks were polished with a rotating polisher (Aropol 2V, Arotec Ind. e Comércio, São Paulo, SP, Brazil) by using silicon carbide sandpaper (3M, Sumaré, SP, Brazil) of decreasing grit (400, 600, 1200) under constant water-cooling. The blocks were also polished with diamond paste (Arotec, São Paulo, SP, Brazil) with grits of 6, 3, 1 and ¼ μm in felt discs (Arotec, São Paulo, SP, Brazil) under cooling with mineral oil. The dentin blocks were smoothed with decreasing grits of sandpaper (600 and 1200) under constant water-cooling. No polishing with felt discs was performed owing to the risk of diamond paste residues accumulating within the dental tubules. The specimens were submitted to ultrasonic water baths (USC 1400, Unique Ind. e Com. de Prod. Elet. LTDA, São Paulo, SP, Brazil) to eliminate residues, between the stages of applying sandpaper grits and pastes[2,4].

The enamel and dentin blocks were randomly distributed into five groups (n=10). The control group (Group 1) did not receive any bleaching treatment, and remained in an artificial saliva solution (1.5mM Ca; 0.9mM P; 20mM Tris buffer; 150mM KCl pH 7.0)[23], for the duration of the experiment.

In the Bleaching and Immediate Restoration (Group 2), Bleaching and Restoration 14 days later (Group 3), Bleaching + Sodium Bicarbonate for 10 minutes (Group 4), and Bleaching and Sodium Bicarbonate for 20 minutes (Group 5), 38% hydrogen peroxide was used as the bleaching agent (Opalescence Boost/ Ultradent Products, South Jordan, UT, USA), which was applied to the tooth surface for three periods of 15 minutes, in accordance with the manufacturer's instructions. A total of 0.2ml of peroxide gel (applied with a plastic syringe) was used for each study specimen[2,4].

The composite resin cylinders (2.5mm in diameter and 4 mm height) fabricated for the shear bond strength tests were built up immediately after the bleaching treatment in the Bleaching and Immediate Restoration group. The cylinders for the group restored 14 days after bleaching were built up after the tooth blocks had been stored in artificial saliva for 14 days, incubated at 37 °C in microbiological oven (Odontobrás, Ribeirão Preto, SP, Brazil), with each study specimen being immersed in 13.5ml of saliva solution.

After the last bleaching session, 10% sodium bicarbonate gel (10% sodium bicarbonate + 1.5% carbopol + 10% propylene glycol + 1.5% triethanolamine + 30 g water) was applied for 10 minutes and 20 minutes, according to the aforementioned groups. Immediately after removal of the bleaching gel, 0.5ml of 10% sodium bicarbonate gel was applied with a disposable brush. The 10% concentration of sodium bicarbonate was chosen since it has been used in previous studies[19,21]. The enamel and dentin surfaces were then rinsed with jets of water/air for 30 seconds. The composite resin cylinders for

the shear bond strength tests were built up immediately after the application of the sodium bicarbonate.

The tooth blocks were submitted to acid etching (35% phosphoric acid, 3M ESPE, Saint Paul, MN, USA) for 15 and 20 seconds for dentin and enamel, respectively. After this, a conventional 2-step adhesive system (Adper Single Bond 2, 3M ESPE, Saint Paul, MN, USA) was applied to the tooth blocks according to the manufacturer's instructions. After 10 seconds of light polymerization using a halogen light (Demetron, LC Kerr Corporation, Orange, CA, USA), the composite resin cylinders (Filtek Z350, 3M ESPE, Saint Paul, MN, USA) were built up on the tooth blocks, incrementally, with the aid of a Teflon matrix measuring 5mm × 2.5mm (height x diameter).

After 24 hours storage in artificial saliva, shear bond strength testing was performed using a universal testing machine (DL 2000, EMIC, São José dos Pinhais, PR, Brazil) at a speed of 0.5 mm/minute. The active point of the machine was positioned so that the force was directed to the bond area. Shear bond strength values were obtained in MPa.

The fractured surfaces of the study specimens were examined using a stereoscopic magnifying glass (Eikonal Equipamentos Ópticos Análiticos, EK3ST, São Paulo, SP, Brazil) at 30x magnification, in order to classify the failure mode. The following types of failure were evaluated for both the enamel and dentin fragments: adhesive (failure of adhesion); cohesive in resin (failure of the composite resin); cohesive in enamel or dentin; and mixed (adhesive and cohesive failure).

The data were analyzed by one-way analysis of variance and the Tukey test, with a 5% level of significance. Enamel and dentin substrates were evaluated as independent variables and they were not compared. Statistical analysis was performed using the SigmaPlot 12.0 software (Systat Software Inc., San Jose, CA, USA).

RESULT

One-way analysis of variance showed that shear bond strength was influenced by post-bleaching treatments received by the enamel and the dentin ($p = 0.022$ and $p = 0.044$, respectively). For enamel, the Tukey test demonstrated that the mean shear bond strength values obtained by the group in which restorations were postponed until 14 days after bleaching treatment were significantly higher than those in the group in which the restoration was placed immediately after bleaching. The mean shear bond strength values for the other groups were intermediate, with no difference between restorations applied immediately and those placed 14 days after bleaching (Table 1).

For dentin, the Tukey test demonstrated that the mean shear bond strength value in the group in which restorations were delayed for 14 days was significantly higher when compared with the group in which sodium bicarbonate gel was applied for 20 minutes. In the groups in which the restoration was placed immediately after bleaching, with sodium bicarbonate gel applied for 10 minutes, and those in which no bleaching treatment was performed, intermediate shear bond strength values were observed (Table 1). Table 2 shows the frequency of premature failures and fracture patterns, and a prevalence of adhesive fractures.

Table 1. Shear bond strength values (MPa) between composite resin restorations and dentin and enamel submitted to different post-bleaching treatments and Tukey test results (α=0.05)

Group	Enamel		Dentin	
	Mean	Standard Deviation	Mean	Standard Deviation
Control	5.99 ab	2.97	3.19 ab	1.62
Bleaching & Immediate Restoration	3.27 b	0.84	2.95 ab	1.33
Bleaching & Restoration 14 days later	6.88 a	2.68	5.97 a	3.64
Bleaching & Sodium Bicarbonate for 10 min	5.59 ab	3.26	4.27 ab	3.24
Bleaching & Sodium Bicarbonate for 20 min	3.96 ab	1.73	2.21 b	1.24

Means followed by different letters in columns highlight a significant difference between groups within each dental substrate (One way ANOVA; $p = 0.022$ for enamel; $p = 0.044$ for dentin). Dental substrates (enamel and dentin) were not compared.

Table 2. Failure mode percentages after shear bond strength tests for enamel and dentin submitted to different treatments

Failure Type	Control		Bleaching & Immediate Restoration		Bleaching & Restoration 14 days later		Bleaching & Sodium Bicarbonate for 10 min		Bleaching & Sodium Bicarbonate for 20 min	
	Enamel	Dentin	Enamel	Dentin	Enamel	Dentin	Enamel	Dentin	Enamel	Dentin
Adhesive	90	75	100	100	100	60	40	100	90	88
Cohesive	0	0	0	0	0	0	0	0	0	0
Mixed	10	25	0	0	0	40	60	0	10	12

DISCUSSION

The present study confirmed a decrease in shear bond strength for both dentin and enamel, when restored immediately after dental bleaching, with significantly lower mean values than the control group that received no bleaching treatment. Therefore, immediate restoration with composite resin should be avoided after bleaching in order to allow time for the residual oxygen on the tooth surface to be eliminated[20]. Spyrides et al.[7] suggested that dentin could be more affected than enamel after hydrogen peroxide-based dental bleaching due to its lower mineral content and larger quantity of organic matrix. Perdigão et al.[21] also suggested that hydrogen peroxide and carbamide peroxide may denature dentin proteins, resulting in alterations to morphology, which could consequently reduce the adhesion of composite resin restorations.

Therefore, it is to be expected that the enamel would be less affected in terms of bond strength than the dentin. Consequently, the effect of sodium bicarbonate could be expected to be more evident in the dentin. The results of the present study, however, showed that sodium bicarbonate did not influence bond strength between the composite resin and enamel or dentin, at both application times, therefore, the null hypothesis was accepted.

In the present study, shear bond strength tests were performed since other studies with regard to bond to enamel or dentin after bleaching also used this method[2-10,12,15-17,20,22]. The use of this methodology can provide more reliable comparisons between the results of this and previous studies.

Sodium bicarbonate or sodium hydrogen carbonate ($NaHCO_3$) is a white crystalline solid, soluble in water. It works as a neutralizer due to its high pH (approximately 8.67), which could destabilize the peroxide molecule, resulting in its decomposition and inactivation[14]. Garcia et al.[19] showed that 10% sodium bicarbonate not only exhibits an antioxidant activity similar to that of sodium ascorbate gel, 10% alpha-tocopherol in an alcohol solution and ascorbic acid gel, but also demonstrates a higher antioxidant activity than catalase. Tostes et al.[22] also observed that the application of 10% sodium bicarbonate solution for 5 minutes may serve as an alternative pre-restorative treatment for bleached enamel. The present study, however, showed that the antioxidant effect of this agent was not sufficient to reverse shear bond strength values when used for 10 and 20 minutes, since no significant difference was found between the groups in which sodium bicarbonate was applied and the groups that underwent bleaching treatment immediately followed by restoration or after 14 days.

The length of time for sodium bicarbonate application used in the present study was based on that proposed by Lai et al.[1], who recommended that the antioxidant agents should be applied for at least a third of the time of the bleaching treatment. Clinically, application times of 10 and 20 minutes are realistic, in terms of times that would be considered practical in dental procedures. Although there was no significant difference between the times used in the present study, it was noted that the mean shear bond strength values for dentin were lower at 20 minutes. Therefore, it may imply that a longer application time could promote lower mean shear bond strength values.

As regards the enamel substrate, in this study results similar to those found by Torres et al.[14] were observed, in which treatment with 7% sodium bicarbonate, applied for 20 minutes, did not reverse the low shear bond strength values after bleaching treatment.

The failure modes after the shear bond strength tests for enamel and dentin submitted to different treatments were similar among groups, with high frequency of adhesive failure. This failure mode is common when performing shear bond strength tests, as has been observed in other studies[2-4,6,12]. Only for enamel, in which the restoration was placed after treatment with sodium bicarbonate gel applied for 10 minutes, there were a lower number of adhesive failures than mixed failure - an unexpected result.

Considering that 10% sodium bicarbonate did not influence the shear bond strength to bleached teeth, for either enamel or dentin, the application of composite resin restorations immediately after treatment with 38% hydrogen peroxide should be contraindicated. Further studies, however, are required in order to define whether the use of antioxidants would be effective in clinical practice.

CONCLUSION

Ten percent sodium bicarbonate gel applied for 10 or 20 minutes was ineffective to reverse the low bond strength to enamel and dentin after bleaching treatment with 38% hydrogen peroxide.

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CONFLICTS OF INTERESTS

The authors declare no conflicts of interest.

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