



## Low-concentrated nonvital bleaching effect on bond strength of composite resin restorations

Efeito de clareadores não-vitais pouco concentrados sobre a força de cisalhamento de restaurações de resina composta

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### CLINICAL RELEVANCE

The low concentration of bleaching agents or its short-term application did not prevent the shear bond reduction of immediate composite resin restorations.

### ABSTRACT

**Objective:** To investigate if short-term dentin bleaching with low-concentrated substances affects the bond strength of immediate resin composite restorations. **Material and Methods:** The buccal surfaces of fifty molar crowns were ground for dentin exposure and randomly assigned into 5 groups (n=10), according to the following treatments: sodium perborate + water; sodium perborate + 6% hydrogen peroxide; 6% hydrogen peroxide; 35% hydrogen peroxide (positive control), or no bleaching agent (negative control). The specimens were immediately restored with resin composite. Seven days after treatments, the shear bond test was performed in a universal test machine at a crosshead speed of 0.5 mm/min. Data were analyzed using ANOVA and Tukey's HSD test ( $\alpha = 0.05$ ). **Results:** The shear bond strength mean values for the negative control group were higher than all experimental and positive control groups ( $p < 0.000$ ), whose differences were not statistically significant ( $p > 0.05$ ). **Conclusion:** Short-term dentin bleaching with sodium perborate+water, 6% hydrogen peroxide, or sodium perborate mixed with 6% hydrogen peroxide reduced the shear bond strength of immediate resin composite restorations.

### KEYWORDS

Resins, synthetic; Hydrogen peroxide; Shear strength; Esthetics; Tooth.

### RESUMO

**Objetivo:** Investigar se o clareamento rápido da dentina com substâncias de baixa concentração afeta a resistência de união ao cisalhamento de restaurações imediatas de resina composta. **Material e Métodos:** As superfícies vestibulares de cinquenta molares foram desgastadas para exposição da dentina e então aleatoriamente alocadas em 5 grupos (n = 10), de acordo com as substâncias clareadoras: perborato de sódio + água; perborato de sódio + peróxido de hidrogênio a 6%; peróxido de hidrogênio a 6%; peróxido de hidrogênio a 35% (controle positivo); ou nenhum agente clareador (controle negativo). Os espécimes foram imediatamente restaurados com resina composta. Sete dias após os tratamentos, testes de resistência ao cisalhamento foram realizados em uma máquina de ensaios universal a uma velocidade de cruzeta de 0,5 mm/min. Os dados foram analisados com os testes ANOVA e Tukey HSD ( $\alpha = 0,05$ ). **Resultados:** Os valores de resistência ao cisalhamento do grupo controle negativo foram maiores do que os dos grupos experimentais e controle positivo ( $p < 0,001$ ), cujas diferenças não foram estatisticamente significativa ( $p > 0,05$ ). **Conclusão:** Clareamentos dentinários rápidos com perborato de sódio, peróxido de hidrogênio 6% ou perborato de sódio misturado com peróxido de hidrogênio 6% reduziram a força de resistência ao cisalhamento de restaurações imediatas de resina composta.

### PALAVRAS-CHAVE

Resinas sintéticas; Peróxido de hidrogênio; Força de cisalhamento; Estética; Dente.

## INTRODUCTION

Intracoronary bleaching is a relatively non-invasive and highly effective procedure for color whitening of discolored root-filled teeth [1]. The oxidative effect that causes the whitening effect, however, may also alter dentin to a level at which its mechanical properties may be compromised [2,3]. Just as important as optimally aesthetic results, a healthy dentin substrate is a basic condition to a stable adhesive union and an adequate sealing of the access cavity after intracoronary bleaching, since it avoids re-contamination with bacteria and improves the fracture resistance of the tooth [4].

Resin composite restorations are bonded to enamel and dentin by means of an acid-etch adhesive technique. Together with ultrastructural defects, the reduction in adhesive polymerization is claimed to respond for provisional bond strength decrease of resin composite restorations following bleaching [1,5-7]. To prevent restorative failures related to these whitening side effects, it is recommended to seal the bleached tooth provisionally until regular shear bond levels are recovered [1,5,6,8].

The active ingredient in all currently used tooth-bleaching materials is basically hydrogen peroxide in its pure form or derived from carbamide peroxide or sodium perborate [2]. The amount of diffused hydrogen peroxide within dental tissues is mostly dependent on hydrogen peroxide concentration in the bleaching product, pH, and the length of time the agent remained into contact with the dentin [9,10]. High-concentrated bleaching agents (25% to 40% hydrogen peroxide) promote optimal whitening tooth effect [2], but besides being caustic, they provide a substantial amount of oxygen to dental tissues [11] and remarkable structural and biochemical alterations even when applied during short time intervals [12,13]. Bond strength reduction and the need for final restoration delay after high-concentrated tooth bleaching has been well described in previous

studies [1,5,6] and even a single 30-minute in-office exposure to 35% hydrogen peroxide was enough to significantly reduce bond strength of immediately dentin bonded restorations [14].

In contrast, low-concentrated hydrogen peroxide bleaching substances present a lower oxidative potential but are also successfully used to internally lighten teeth, although some delay might be expected [15]. When mixed with water, sodium perborate did not produce ultrastructural changes in dental tissues [13], did not increase dentinal tubule diameter nor promoted organic and inorganic alterations of dentin components [16]. A long lasting dentin exposure to sodium perborate, however, impaired resin composite adhesion [5].

Once shear bond strength reduction after bleaching might be related to the amount of diffused hydrogen peroxide within dental tissues, the hypothesis tested was that short-term dentin bleaching with low-concentrated substances (6% hydrogen peroxide, sodium perborate mixed with water or sodium perborate mixed with 6% hydrogen peroxide) does not affect bond strength of immediate resin composite restorations as 35% hydrogen peroxide does.

## MATERIAL AND METHODS

The study protocol was reviewed and approved by the Ethics Committee in Research of the University of São Paulo and it is in accordance with 2008 Helsinki Declaration.. Fifty freshly-extracted human lower third molars were cleaned, examined under 16x magnification (DFV, São Paulo, SP, Brazil) to discard those with caries, fissures, or defective grooves, and stored in 4°C distilled water for 3 months. For specimen preparation, each tooth was placed with the buccal face down at the end of silicon cylinders (i.d. 15 mm x 15mm height), which were then filled with chemically-activated epoxy resin (Redelease, São Paulo, SP, Brazil). After 24 hours, the silicon cylinder was removed and the buccal side of each tooth

was ground under water cooling with #400- and #600-grit silicon carbide sandpapers (Norton®, Guarulhos, SP, Brazil), adapted in a slow-speed polishing machine set at 150 rpm (DP-92 Panambra Industrial, São Paulo, SP, Brazil), up to exposed dentin (Figure 1). The sample was kept in distilled water at 37°C for seven days.

The specimens were randomly assigned to five groups (n = 10), according to the bleaching treatment tested. The specimens in group I (negative control) received no bleaching and they were stored at 37°C in distilled water during the experimental period that preceded the shear strength test. In group II, samples were bleached with sodium perborate (Whiteness Perborato, FGM Dentscare, Joinville, SC, Brazil) mixed with distilled water in the proportion of 2:1, to produce a paste. In group III, sodium perborate was mixed with 6% hydrogen peroxide (Pharmácia Específica, Bauru, SP, Brazil) in the ratio of 2:1, as group II. In group IV, samples were bleached with 6% hydrogen peroxide, and in group V, high-concentrated hydrogen peroxide (35%) (Pharmácia Específica, Bauru, SP, Brazil) was used (positive control). Minimal amounts of bleaching agents were equally applied to cover the entire dentin extent for 60 minutes, in a single application, and then the substances were removed from the surface through washing with five millilitres of distilled water before the immediate initiation of restorative procedures.

The surfaces of dentin specimens were etched for 15 s with 37% phosphoric acid gel (Condac, FGM Dentscare, Joinville, SC, Brazil), rinsed with water for 15 s, and dried briefly, leaving a moist surface. Two consecutive coats of the adhesive system (Adper™ Single Bond 2, 3M ESPE, St. Paul, MN, USA) were applied, lightly air-dried for 2 s, and light cured (Curing Light, 3M Espe, St. Paul, USA) for 10 seconds, according to the manufacturer's instructions for bonding procedures. A bipartite polyteflon ring mold, with a circular central hole presenting



**Figure 1** - Specimen preparation. A - Dentin exposed after grinding. B - Resin composite restoration built on dentin.

3.57 mm in diameter and 2.0 mm in depth, was positioned over the treated flat surface. The mold was filled with a hybrid composite resin (Z100, 3M ESPE, St. Paul, MN, USA) and light cured for 40 seconds after each one of the two layers was inserted. The specimens were then immersed in distilled water and stored for 7 days at 37°C before testing.

The shear bond strength was measured in a universal test machine (Emic DL-500, São Jose dos Pinhais, SP, Brazil) using the orthodontic edge wire-loop method. An orthodontic wire was aligned over the sample holder, forming a loop around the cylindrical resin composite adjacent to the dentin surface, and the specimen was loaded to failure using a crosshead speed of 0.5 mm/min.

Means and standard deviations were calculated and expressed in megapascals (MPa). The data were subjected to the analysis of variance (ANOVA) and Tukey's HSD test for multiple comparisons, both adjusted to the 5% significance level. All analyses were conducted using SPSS v.18.0 for Windows (IBM, Chicago, IL, USA).

## RESULTS

Table 1 shows the standard deviations (MPa) of bond strength. ANOVA showed statistically significant differences among groups ( $p < 0.0001$ ). Tukey's HSD test ascertained that the unbleached group I had the highest mean bond strength and differed significantly from all experimental groups, whose differences were not statistically significant ( $p > 0.05$ ).

**Table 1** - Means and standard deviations (MPa) of bond strength at dentin/resin composite after tooth bleaching with tested agents

Group	Bleaching substance	Bond strength
I	distilled water (negative control)	18.53 ( $\pm 5.00$ ) <sup>b</sup>
II	sodium perborate + distilled water	9.11 ( $\pm 4.95$ ) <sup>a</sup>
III	sodium perborate + 6% hydrogen peroxide	7.00 ( $\pm 2.97$ ) <sup>a</sup>
IV	6% hydrogen peroxide	4.58 ( $\pm 4.00$ ) <sup>a</sup>
V	35% hydrogen peroxide (positive control)	4.09 ( $\pm 2.59$ ) <sup>a</sup>

The same lowercase letters represent a homogenous subset between groups ( $p > 0.05$ ).

## DISCUSSION

Diverse products are available for tooth bleaching in the form of gels and containing varying concentrations of hydrogen peroxide combined with few other substances like stabilizers, catalysts and flavor agents [17]. In this experiment the bleaching agents were tested in their pure presentation form, as implemented in other studies, to avoid bias due to an eventual influence of those additional substances [1,6]. In addition, the whitening agents were not sealed intracoronally [5,18] but applied over the dentin surface, as performed by Carrasco-Guerisoli et al. [10] and, for this reason, the oxygen released during oxidative agents decomposition was not forced inside dentinal tubules by the resulting pressure increase [19], and thus the shear bond reduction observed on experimental and positive control groups may have been underestimated.

The adhesion of resin composite to dentin is attributed to a mixture of micromechanical

interlocking and chemical interactions of functionalized monomers with apatite [20]. These mechanisms could justify the high bond strength values detected for the negative control group (unbleached), in line with those results described by Nujella et al. [21]. Oppositely, the significant bond strength reduction detected after 35% hydrogen peroxide usage was well described in previous studies [1,5,6,18,19]. In spite of the fact that 35% hydrogen peroxide solution alters the structural and biochemical properties of enamel and dentin substrate [11], the amount of oxygen incorporated into tooth structure during the short application time might also have caused a reduction in the extent that adhesive polymerization interpenetrated into dentin [20].

In this study, both sodium perborate and 6% hydrogen peroxide, alone or mixed, reduced the SBS value of resin composite to dentin, a result already described in the study of Vieira et al. [6]. Despite the lower peroxide availability, 6% hydrogen peroxide caused a bond strength reduction as prominent as that observed for the high-concentrated 35% solution. It is suspected that the shear bond reduction detected might be due, at first, to a demineralization of dentin inorganic component caused by the inherent acidic pH of the hydrogen peroxide solution. The immediate 37% phosphoric acid conditioning and resulting overexposure to etching may have also contributed to reduce the bond strength of the adhesive applied [22], once the defective monomeric layer formed might have been more susceptible to polymerization inhibition by the remaining oxygen inside dentin.

Differently from hydrogen peroxide solutions, alkaline sodium perborate presents a lower hydrogen peroxide diffusion and depth of penetration into dentin [23]. The results obtained showed that sodium perborate mixed with water reduced the shear bond strength of composite resin similarly to 35% hydrogen peroxide, a result also described in other studies [5,18,19]. Bleaching non-vital teeth with sodium perborate plus water did not produce ultrastructural changes in dental hard tissues



[16] and thus one might suspect that the bond strength decrease detected could be related to the amount of oxygen incorporated into dentin, smaller and more superficial than that of 35% hydrogen peroxide [23], but apparently enough to impair adhesive polymerization inside dentin substrate. The influence of whitening on the conversion degree of dental adhesives also depends on the susceptibility of the adhesive system [20], and thus different results could be expected if adhesives of varied compositions were adopted. It should be also taken into account that shear bond strength tests were performed right after bleaching and therefore it may not have had time enough to leach hydrogen peroxide nor bleaching substances residues that may have prevented the adequate impregnation of monomer blends into dentin, as supposed by Shinohara et al. [5], thus responding for the bonding decrease detected in all experimental groups.

The 60-minute whitening session was previously adopted by Titley et al. [24] and, despite being closer to a non-vital in-office session [2], caution should be taken when comparing our results with those of longer exposures to sodium perborate such as those of Teixeira et al. [18], who detected even lower bond strength values in the interval of 28 days. Despite some oxygen may have entered into dentin, the efficiency of the low-concentrated agents tested for promoting intracoronal bleaching in short time intervals, like the one investigated in this study, is still unknown.

The results observed in this experiment allowed us to accept the hypothesis that short-term intracoronal bleaching with the low-concentrated agents investigated affected negatively the bond strength of immediate resin composite restorations as 35% hydrogen peroxide. Of clinical significance, our findings suggest that neither the type nor the substance concentration seem to be a determining factor to decide if a resin composite restoration should or not be immediately performed after nonvital

bleaching, even if it is applied during a short time interval. The recommended delay of 1-3 weeks for compromised bonding reversal after high-concentrated bleaching [1,8] may also be required when the low-concentrated whitening substances investigated in this research are applied intracoronal. Nevertheless, it should be clear that laboratory tests do not reproduce intraoral conditions; whether the degrees of bond strength reduction are sufficient to affect the clinical performance of access cavity restoration immediately after intracoronal bleaching has yet to be determined.

## REFERENCES

1. Souza-Gabriel AE, Vitussi LO, Milani C, Alfredo E, Messias DC, Silva-Sousa YT. Effect of bleaching protocols with 38% hydrogen peroxide and post-bleaching times on dentin bond strength. *Braz Dent J.* 2011;22(4):317-21.
2. Zimmerli B, Jeger F, Lussi A. Bleaching of nonvital teeth. A clinically relevant literature review. *Schweiz Monatsschr Zahnmed.* 2010;120(4):306-20.
3. Forner L, Salmeron-Sanchez M, Palomares M, Llena C, Amengual J. The use of atomic force microscopy in determining the stiffness and adhesion force of human dentin after exposure to bleaching agents. *J Endod.* 2009 Oct;35(10):1384-6. doi: 10.1016/j.joen.2009.06.023.
4. Azevedo RA, Silva-Sousa YT, Souza-Gabriel AE, Messias DC, Alfredo E, Silva RG. Fracture resistance of teeth subjected to internal bleaching and restored with different procedures. *Braz Dent J.* 2011;22(2):117-21.
5. Shinohara MS, Peris AR, Rodrigues JA, Pimenta LA, Ambrosano GM. The effect of nonvital bleaching on the shear bond strength of composite resin using three adhesive systems. *J Adhes Dent.* 2004 Autumn;6(3):205-9.
6. Vieira C, Silva-Sousa YT, Pessarello NM, Rached-Junior FA, Souza-Gabriel AE. Effect of high-concentrated bleaching agents on the bond strength at dentin/resin interface and flexural strength of dentin. *Braz Dent J.* 2012;23(1):28-35.
7. Ramos CM, Bim Junior O, Rodrigues RF, Maenosono RM, Alencar MS, Wang L, et al. Bonding to bleached enamel treated with 10% sodium bicarbonate: a one-year follow-up. *Braz Dent Sci.* 2014 Oct/Dec;17(4):119-24.
8. Hansen JR, Frick KJ, Walker MP. Effect of 35% sodium ascorbate treatment on microtensile bond strength after nonvital bleaching. *J Endod.* 2014 Oct;40(10):1668-70.
9. Hanks CT, Fat JC, Wataha CJ, Corcoran JF. Cytotoxicity and dentin permeability of carbamide peroxide and hydrogen peroxide vital bleaching materials in vitro. *J Dent Res.* 1993 May;72(5):931-8.
10. Carrasco-Guerisoli LD, Schiavoni RJ, Barroso JM, Guerisoli DM, Pécora JD, Fröner IC. Effect of different bleaching systems on the ultrastructure of bovine dentin. *Dent Traumatol.* 2009 Apr;25(2):176-80.
11. Palo RM, Valera MC, Camargo SE, Camargo CH, Cardoso PE, Mancini MN, et al. Peroxide penetration from the pulp chamber to

- the external root surface after internal bleaching. *Am J Dent.* 2010 Jun;23(3):171-4.
12. Sato C, Rodrigues FA, Garcia DM, Vidal CM, Pashley DH, Tjäderhane L, et al. Tooth bleaching increases dentinal protease activity. *J Dent Res.* 2013 Feb;92(2):187-92.
  13. Chng HK, Yap AU, Wattanapayungkul P, Sim CP. Effect of traditional and alternative intracoronal bleaching agents on microhardness of human dentine. *J Oral Rehabil.* 2004 Aug;31(8):811-6.
  14. Bittencourt ME, Trentin MS, Linden MS, de Oliveira Lima Arsati YB, França FM, Flório FM, et al. Influence of in situ post bleaching times on shear bond strength of resin-based composite restorations. *J Am Dent Assoc.* 2010 Mar;141(3):300-6.
  15. Lim MY, Lum SOY, Poh RSC, Lee GP, Lim KC. An in vitro comparison of the bleaching efficacy of 35% carbamide peroxide with established intracoronal bleaching agents. *Int Endod J.* 2004 Jul;37(7):483-8.
  16. Maleknejad F, Ameri H, Kianfar I. Effect of intracoronal bleaching agents on ultrastructure and mineral content of dentin. *J Conserv Dent.* 2012 Apr;15(2):174-7.
  17. Dietschi D, Rossier S, Krejci I. In vitro colorimetric evaluation of the efficacy of various bleaching methods and products. *Quintessence Int.* 2006 Jul-Aug;37(7):515-26.
  18. Teixeira EC, Turssi CP, Hara AT, Serra MC. Influence of post-bleaching time intervals on dentin bond strength. *Braz Oral Res.* 2004 Jan-Mar;18(1):75-9.
  19. Chng HK, Palamara JE, Messer HH. Effect of hydrogen peroxide and sodium perborate on biomechanical properties of human dentin. *J Endod.* 2002 Feb;28(2):62-7.
  20. Cadenaro M, Breschi L, Antonioli F, Mazzoni A, Di Lenarda R. Influence of whitening on the degree of conversion of dental adhesives on dentin. *Eur J Oral Sci.* 2006 Jun;114(3):257-62.
  21. Nujella BP, Choudary MT, Reddy SP, Kumar MK, Gopal T. Comparison of shear bond strength of aesthetic restorative materials. *Contemp Clin Dent.* 2012 Jan;3(1):22-6.
  22. Duschner H, Götz H, White DJ, Kozak KM, Zoladz JR. Effects of hydrogen peroxide bleaching strips on tooth surface color, surface microhardness, surface and subsurface ultrastructure, and microchemical (Raman spectroscopic) composition. *J Clin Dent.* 2006;17(3):72-8.
  23. Hannig C, Weinhold HC, Becker K, Attin T. Diffusion of peroxides through dentine in vitro with and without prior use of a desensitizing varnish. *Clin Oral Investig.* 2011 Dec;15(6):863-8.
  24. Tittley K, Torneck CD, Smith DC. Effect of concentrated hydrogen solution on the surface morphology of cut human dentin. *Endod Dent Traumatol.* 1988 Feb;4(1):32-6.

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