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Effect on composite-enamel bond strength using reducing solutions after dental bleaching

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• Conflicts of interest: none declared.

Abstract

Objective: to evaluate the bond strength of composite resin to bovine enamel after bleached surfaces were treated with two different reducing substances. **Material and Methods:** bovine teeth were embedded, had their buccal face planed and were divided into 4 groups (n=10). Group 1 (control) was not subjected to bleaching, acid etched and restored with adhesive and composite resin. Groups 2 to 4 were bleached with 35% hydrogen peroxide during 4 consecutive days for 40 min/session and subjected or not to the proposed surface treatments before being restored. Group 2 was bleached and restored, while Groups 3 and 4 were bleached and immersed in sodium thiosulfate or sodium ascorbate solution, respectively, before being restored. Samples were stored for 24 hours and then submitted to a microshear strength test. **Results:** according to the statistical tests, the bond strength results using reducing agents were similar to those of the control group and statistically different from those of the only-bleached group. **Conclusion:** the reducing solutions were capable of recovering the bond strength of freshly bleached teeth without statistically significant difference between them.

Keywords: Tooth bleaching; Reducing solutions; Composite resins; Adhesiveness.

Introduction

From the analysis of the smile, shape and lip contour, gingival exposure while smiling, dominance and apparent brightness of the central incisors, the dentist can use digital technologies and adhesive materials to improve in a minimally invasive manner the luminosity and beauty of the smile.[1,2] Tooth bleaching is currently part of the first stage of an esthetic restorative plan, considering that less invasive preparations and adhesive restorations achieve more promising results if there is a considerably clear base to start.[2,3]

Home bleaching uses bleaching agents as carbamide peroxide at concentrations from 10 to 22% and hydrogen peroxide at concentrations from 3 to 16%. In-office bleaching is carried out with hydrogen or carbamide peroxide at concentrations between 30 and 35%.[3] In general, in-office bleaching sessions have duration up to 40 minutes and, according to the manufacturer, the treatment should not exceed four sequential sessions with 24-hour to 1-week intervals between them in order to ensure safety to enamel structure integrity.[4-6]

Due to impregnation of oxygen into the tooth structure, a result of bleaching agent degradation, it is recommended to wait 7 to 15 days to restore bleached teeth with adhesive materials. This time is aimed at eliminating residual oxygen, which could impede an effective polymerization of composite resins and adhesives, resulting in a decrease in bond strength and early displacement of the restoration.[7-10]

However, there will be situations where waiting 7-15 days to restore a tooth may not be a viable choice, either for personal needs; in cases where there could occur a great color difference between teeth restored prior to bleaching and the other healthy bleached teeth; or due to the risk of contamination, in cases of endodontically treated teeth.[11,12]

Some solutions are indicated for irrigating endodontically treated teeth in order to shorten the waiting time for placing an adhesive restoration. Reducing agents, such as sodium ascorbate and sodium thiosulfate at different concentration can neutralize the residual oxygen, thereby increasing the adhesiveness of composite resin restorations to enamel and dentin.[13-17]

Previous studies have evaluated the effect of sodium ascorbate and sodium thiosulfate as reducing agents for endodontic purposes.[13,14] Furthermore, the effect of sodium ascorbate as a reducing agent after bleaching has shown promising results in recovering bond strength.[18,20] Therefore, this study suggested the use of sodium ascorbate and sodium thiosulfate solutions, already successfully employed in endodontically treated teeth, for application in cases of external bleaching. The tested hypothesis is that sodium ascorbate and sodium thiosulfate would be able to recover the bond strength, probably with different oxidative potential from each other, when used immediately after external bleaching. A comparison was made with the bond strength obtained in a control group not subjected to bleaching.

Material and Methods

Treatment of Bovine Tooth Surface

Forty bovine teeth stored in distilled water under refrigeration were used in the study. The roots were removed transversally and the crowns were sectioned longitudinally in a mesiodistal direction using a diamond disk (KG Sorensen,

SP, Brazil) to separate the lingual from buccal faces, which were used as test samples. The samples were embedded in epoxy resin (Percilglass, SP) with the buccal face turned upwards, flattened by a decreasing sequence of sandpapers (#240-, #400- and #600-grit) for further fixation 3-mm-high urethral probe tubes (Embramed n. 8, ON). These tubes were filled with composite resin A2 (Z100; 3M/ESPE, St. Paul, MN, USA).

The samples were divided into 4 groups (n=10), cleaned with pumice/water in Robinson brushes for 10 seconds to remove any traces of oil or enamel powder, rinsed thoroughly in running water and bench dried on absorbent paper (Table 1).

Table 1. Description of experimental groups

Groups	Description
Control (Control)	No treatment of tooth surface.
Group 2 to 4	Bleaching with hydrogen peroxide for 4 consecutive days for 40 min/session.
Group 2	Bleaching + acid etching + adhesive + composite resin.
Group 3	Bleaching + immersion in 10 mL 10% sodium thiosulfate for 60 s + acid etching + adhesive + composite resin.
Group 4	Whitening + immersion in 10 mL 10% sodium ascorbate for 60 s + acid etching + adhesive + composite resin.

Group 1 (control group) was not subjected to bleaching. The samples were etched with 35% phosphoric acid (Ultra Etch, Ultradent, USA) for 20 s, washed in running water for 20 s, Scothbond Multipurpose adhesive (3M ESPE) was applied with a microbrush, and composite resin A2 was inserted into the tubes and light-cured with a LED curing unit (Radii - lime, SDI, Australia) for 40 s. The tubes were cut longitudinally and discarded, and all restored samples were stored in a humid environment at 37ºC. After 24 hours, the microshear strength test was performed in a universal testing machine (DL line 1000, 10kN maximum capacity, EMIC, São José dos Pinhais, PR, Brazil). Groups 2 to 4 were subjected to bleaching with 35% hydrogen peroxide (Whiteness Blue HP – FGM, Blumenau, SC) during 4 consecutive days for the time of 40 min each session, following the manufacturer's instructions for duration of sessions and treatment. After each bleaching session, the samples were washed in running water for 20s and immersed in distilled water so that bleaching was performed again in the following day. On the 4th day, the experimental groups were subjected to different surface treatments before being acid etched and restored as described for Group 1. All restored samples were stored in a humid environment at 37 ºC and subject the microshear strength test after 24 hours (Figure 1).

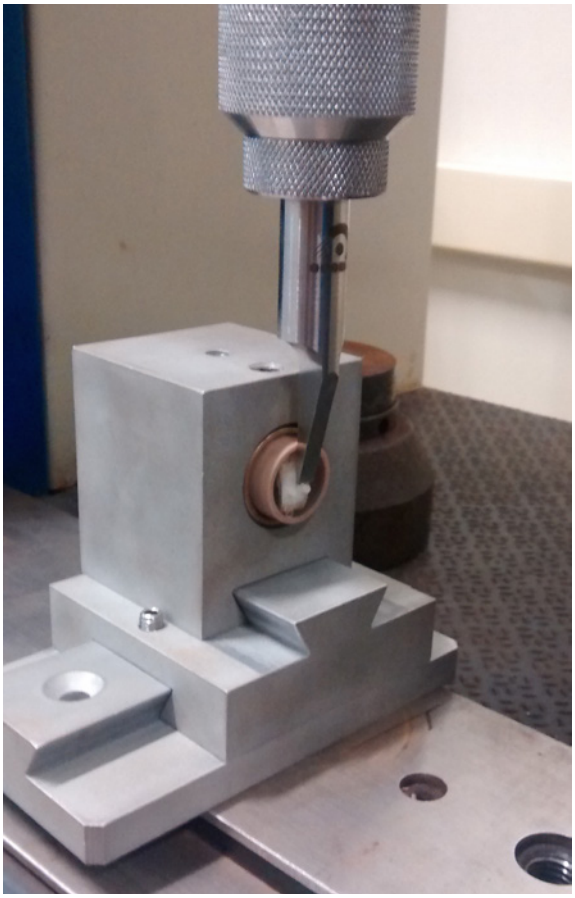

Figure 1. Buccal face of the embedded sample with an attached composite resin cylinder and a beveled tip positioned at a 90º angle for the microshear strength test in an Emic universal testing machine

The samples in Groups 2 to 4 were subjected to the following treatments:

Group 2: After the bleaching protocol, the samples were immediately etched with phosphoric acid for 20s, rinsed for 20s, gently air dried, coated with an light-cured adhesive layer, and restored with a light-cured composite resin.

Groups 3 and 4: These groups were subjected to the same bleaching protocol as Group 2, and in the last day, the samples were immersed in 10 mL of 10% sodium thiosulfate (Group 3) or 10% sodium ascorbate (Group 4) (Mil Fórmulas Farmácia de Manipulação, Rio de Janeiro, RJ, Brazil) for 60s. After this time, excess solution on the surface was eliminated with compressed air drying and the same restorative procedure described for the other groups was performed.

All restored samples were stored in a humid environment at 37ºC and subject the microshear strength test after 24 hours (Figure 1).

Microshear Strength Test

For the microshear strength test, a beveled test tip was adapted at the interface between the composite resin cylinder and the buccal face with 200kg load cell running at crosshead speed of 0.5 mm/s until failure occurred (Figure 1). The displacement force was recorded in N. Data were

introduced in a software that converted the tension values into MPa. Height and diameter data were introduced in a software that converted the tension values into MPa using the equation F = H x d, where F is force, H is height and d is diameter.

Statistical Analysis

Normality of data and equality of variances were assessed using the Kolmogorov-Smirnov and Levene's tests, respectively. As there was no homogeneity of variance and normal distribution, Kruskal-wallis and Dunn tests were used for analysis of data ($p<0.05$).

Results

The microshear test data were expressed as tension measured in MPa for the different groups evaluated. Table 2 shows the microshear bond strength means and standard deviations. The values were analyzed statistically significant difference by the Kruskal-wallis and Dunn tests, as described in Figure 2. According to the statistical tests, the bond strength results using reducing agents (Groups 3 and 4) were similar to those of the control group (Group 1) and statistically different from those of the only-bleached group (Group 2).

Table 2. Microshear bond strength (in MPa) and standard deviation of the control group, bleached group and groups subjected to surface treatment

Samples	Bond strength (MPa)	Standard deviation
Group 1 (Control)	39.974	12.92
Group 2	24.612	17.29
Group 3	43.203	9.43
Group 4	43.378	7.66

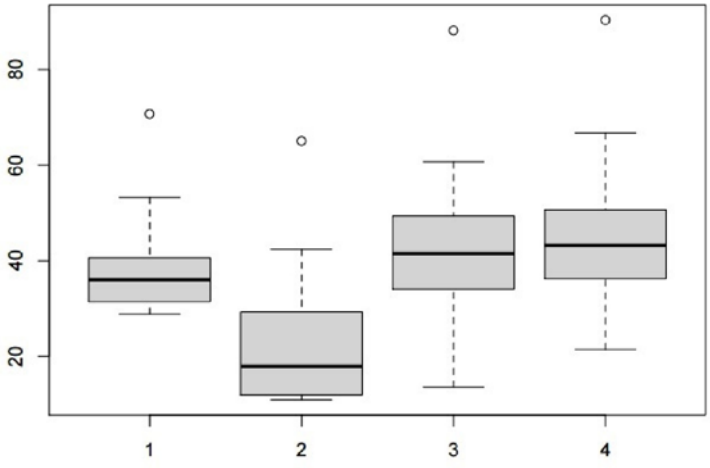

Figure 2. Descriptive statistics of the union resistance values of both groups. Y axis represented by the median values and the x - axis numer tion groups. Bottom table expressed in numbers, with the results of the means of the 4 groups. Descriptive statistics of the bond strength values of both groups. The Y axis represents the medians and X axis represents the groups. Bottom table expressed in numbers with mean values of the 4 groups

Discussion

The cause of early failure of adhesive restorations after bleaching is due to oxygen impregnation in the tooth structure, regardless of the bleaching technique.[3,4,8,10,20,21] The dental structure remains for some time impregnated with oxygen, product of hydrogen peroxide or carbamide degradation, which affects the polymerization of resinous materials and contraindicates the use of adhesive materials immediately after the completion of a bleaching treatment.[8,9,21,22]

In the present study, lower microshear strength values were obtained in the teeth restored immediately after completion of bleaching compared with the non-bleached control group. These results show similar values to those of other authors who do not recommend the placement of adhesive restorations in bleached teeth before 7 to 15 days.[9,10,21,22] As methodologies vary considerably, there are studies which did not find variation in bond strength values between control and bleached groups.[6,8-10] However, in the present study, the adhesive restoration was placed immediately after completion of the last bleaching session for the bond strength test, which could have influenced the obtained results.[18,19]

Due to the difficulty in obtaining human teeth in a standardized manner, bovine teeth were used as an alternative substrate, as they are histologically and morphologically similar to human teeth.[20,21,23.25] Bovine teeth have widely been employed in bond strength testing.[20,24,25] Thus, the bond strength results obtained after bleaching using bovine teeth can be comparable to those of other studies because of the similarity between the histological structure of human and bovine teeth for adhesion tests.[13,21,25]

Studies that used sodium ascorbate and sodium thiosulfate at 5 to 10% concentrations as reducing solutions with irrigation times between 60 and 300s right after intraradicular bleaching without washing, only drying the solution, and immediate placement of an adhesive restoration obtained similar results to those of the control groups even after thermal cycling.[13,14] The methodology of the present study was based on studies whose best outcomes were obtained with the use of 10% sodium thiosulfate. As a potent vitamin C-based reducing agent was also used, sodium ascorbate, it was decided to employ this solution at the same concentration (10%) for comparison purposes. Sodium ascorbate is an antioxidant compound capable of acting on free radicals, having a protective action against the damage induced by hydrogen peroxide in biological systems. Likewise, as a potent antioxidant agent, sodium thiosulfate should be introduced into the root canal, when used in internal bleaching, before unchaining of the oxidative cascade, acting on the products of hydrogen peroxide degradation.[13-15,17]

In this study, the mean bond strength was 43 MPa after use of the reducing solutions for 60s, followed by acid etching, enamel adhesive application and composite resin restoration. As the samples were subjected to external bleaching, the methodology used in endodontically treated teeth was adapted by employing a 60-s immersion time. This time

was defined based on the results of studies that obtained bond strength values similar to the control group employing reducing agents for the time of 60 s, which is clinically viable.[13,15,20] In Groups 3 and 4, the bleached samples were immersed in 10% sodium ascorbate and sodium thiosulfate solutions, respectively. As there is evidence of the efficiency of these two solutions, the 10% concentration was selected in order to have equal comparison conditions.[15,18,19] The result of the immersion in the solutions for 60s showed a similar adhesive response between the solutions, and both were similar to the control group, in the same way as observed in other studies with endodontically treated teeth.[13,15,18,19] As the immersion in 10 mL of solution is comparable to the volume used for intraradicular irrigation in endodontic clinic, the use of the same volume of solution by gauze saturation on enamel surface for the 60s in cases of external bleaching proves to be a realistic clinical conduct that can be easily performed.[17,18]

Conclusion

According to the obtained results, it can be concluded that the tested hypothesis was partially confirmed since the reducing solutions used to treat enamel surface after external bleaching were able to recover the bond strength to values similar to those obtained on nonbleached surface, without, however, showing a superior oxi-reducing potential between them.

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Mini Curriculum and Author's Contribution

1. Nathalia Nery Pinheiro Póvoa - graduate student. Contribution:
effective scientific and intellectual participation in the study; data collection; data interpretation; manuscript preparation; manuscript writing.
2. Juliana das Neves Marques – postgraduate student. Contribution: effective scientific and intellectual participation in the study; data collection.
3. Renata Aunton Simão – DDS and PHD. Contribution: effective scientific and intellectual participation in the study; study conception and design; data collection; data interpretation; manuscript preparation; manuscript writing; critical review.
4. Maíra do Prado - DDS and PHD. Contribution: effective scientific and intellectual participation in the study; study conception and design; data collection; data interpretation; manuscript preparation; critical review and final approval.
5. Marta Cléa Costa Dantas – DDS. Contribution: effective scientific and intellectual participation in the study; study conception and design; data collection; data interpretation; manuscript preparation; manuscript writing; critical review and final approval.

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