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ORIGINAL RESEARCH

Can Whitening Strips interfere with the Bond Strength of Composite Resins?

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ABSTRACT

Aim: The aim of this study was to investigate *in vitro* the bond strength of composite resins on enamel previously treated with whitening strips.

Materials and methods: A total of 48 bovine incisors were allocated to four experimental groups (n = 12 each): G1 (WSC)—treated with 9.5% hydrogen peroxide whitening strips (3D White Whitestrips® Advanced Vivid/CREST); G2 (WSO)—treated with 10% hydrogen peroxide whitening strips (3D WhiteTM/Oral B); G3 (WG)—treated with 7.5% hydrogen peroxide gel with fluorine, calcium and potassium nitrate (White Class®/FGM); and G4 (C)—control not subjected to bleaching treatment. The specimens were subjected to bleaching over 2 weeks following the manufacturers' instructions. Following the elaboration of the composite resin test specimens, the samples were stored in artificial saliva and subsequently subjected to the microshear test using the universal testing machine (EMIC®). The bond strength values were analyzed by one-way ANOVA and Tukey's statistical test (5%).

Results: Significant differences were observed among the investigated groups ($p < 0.05$). The G3-WG exhibited greater values compared with the control group and the groups treated with strips, G1-WSC and G2-WSO. Analysis of the bond interface revealed that a large fraction of the failures occurred at the enamel-resin interface.

Conclusion: The bond strength decreased following 14 days of treatment with bleaching strips, whereas the whitening gel with 7.5% hydrogen peroxide, calcium and fluorine increased the bond strength.

Keywords: Dental enamel, Tooth bleaching, Adhesives.

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INTRODUCTION

As a function of the great value attributed to esthetics in the field of dentistry, bleaching systems are undergoing considerable advances. At-home tooth whitening has exhibited wide clinical applications since its introduction by Haywood and Heymann in 1989.[1] At-home bleaching has become increasingly popular, and in many cases, it is used as an adjuvant in esthetic rehabilitation treatments due to its conservative nature, proved efficacy, low cost, and supervised self-application.

In addition to the high-concentration bleaching agents indicated for use in dental practices,[2,3] some low-concentration products are directly available to the consumers. The latter can be applied at-home using customized or preformed trays, brushes or strips.[3,4]

Although any bleaching procedure ought to be performed or supervised by a dentist,[3,4] bleaching agents are purchased and used indiscriminately, without professional diagnosis and prescription.[3] Because of an increasing need for whiter teeth and easy access to bleaching agents, whitened teeth are becoming increasingly more frequent findings in dental practices.

As bleaching agents, carbamide peroxide and hydrogen peroxide do not whiten the materials used in restorations; the latter usually need to be changed after bleaching.[3] However, the bond strength of resinous materials to the teeth is temporarily reduced following bleaching,[3,5-7] which might be associated with bond failure and the risk of micro-infiltrations, which threaten the longevity of restorations.

Hydrogen peroxide is the agent most widely used for tooth bleaching. In contact with the enamel surface, hydrogen peroxide decomposes into water and oxygen, which diffuse through the enamel and oxidize organic pigments, thus reducing the number of dark pigments.[8] Impaired bond strength is mainly associated with the presence of residual oxygen within the tooth structure. Scanning electron microscopy (SEM) and fracture resistance tests indicate that the reduction of the bond strength might be associated with impaired resin ability to attack hydrogen peroxide-treated surfaces.[5]

The wide range of bleaching agents[3,4] and the permanent quest for whiter teeth, highlights the need for studies that evaluate the behavior and performance of low-concentration bleaching agents. The development of novel bleaching systems that are available in the market suggests the relevance of studies assessing bond techniques in teeth whitened at-home. Unfortunately, the available studies have not reported the influence of bleaching strips on the bond strength of composite resin.

Based on the discussion above, the aim of the present study was to assess the bond strength of composite resin following bleaching using low-concentration hydrogen peroxide strips or gel. The tested null hypothesis states that there is no significant difference in the bond strength of teeth subjected to the different methods of at-home whitening using hydrogen peroxide compared to non-treated enamel.

MATERIALS AND METHODS

A total of 48 freshly extracted, healthy bovine incisors were used. The study was approved by the Animal Experimentation and Ethics Committee of the State University of Maranhão (UEMA), process no. 07/2012. The inclusion criteria were as follows: healthy teeth not subjected to previous treatment and without cracks, fractures, or exposed dentin.

Following teeth selection, the roots were cut at the cervical third and discarded. The pulp chamber was opened, the coronal pulp was removed, and the specimens were irrigated using distilled water and dried. The pulp chamber was obliterated using utility wax (Epoxiglass Ind Com, Diadema, Brazil) to avoid penetration of the acrylic resin used for mounting.

The teeth were placed in PVC tubes for acrylic resin mounting (Jet-classico, São Paulo, Brazil) so that the vestibular surfaces were in proper position for treatment. The teeth were randomly allocated to four experimental groups (n = 12 each): G1 (WSC) treated with 9.5% hydrogen peroxide/Whitening strips (3D White Whitestrips® Advanced Vivid/CREST, Cincinnati, USA); G2 (WSO)—treated with 10% hydrogen peroxide/Whitening strips (3D WhiteTM/Oral B, Rockford, USA); G3 (WG)—treated with 7.5% hydrogen peroxide gel (White Class® FGM, Joinvile, Brazil); and G4 (C)—without whitening treatment (control group). The teeth were stored in artificial saliva (FACIAL, São Luis, Brazil), and the treated groups were subjected to bleaching over 2 weeks following the manufacturers' instructions, thus reproducing the at-home treatment.

At the end of 2 weeks, the teeth vestibular surface was cleansed with pumice (SS White, Rio de Janeiro, Brazil), water was applied using a polishing brush (Microdont, São Paulo, Brazil), and the enamel was dried. Twenty-four hours after the end of the bleaching treatment, acid conditioning was performed at the middle third of the enamel vestibular surface using 37% phosphoric acid (Dentsply, Petrópolis, Brazil), over 30 seconds, which was later removed by irrigation with abundant water for 30 seconds, and the teeth were dried.

The adhesive system Adper Single Bond 2 (3M ESPE, St Paul, USA) was applied, and four 0.75 mm wide and 1 mm high clear cylindrical matrices (Tygon tubing, Saint-Gobain Performance Plastic, Maime Lakes, USA) were placed on the conditioned enamel surface. Composite resin Filtek Z250 (3M ESPE, St Paul, USA) was placed inside the tube, and photopolymerization was performed over 40 seconds using the Optilux 501 device (Kerr/Demetron, Orange, USA) with light intensity of 600 mW/cm^2.

The samples were stored in artificial saliva at 37 ± 1°C for 24 hours, and then the tubes were carefully removed using a scalpel blade. For the micro-shear test, the samples were placed in a device coupled to a universal test machine (EMIC DL-2000, São José dos Pinhais, Brazil). A steel wire with a cross section of 0.20 mm (Morelli Ortodontia, São Paulo, Brazil) was placed in the bottom of the cylinder, allowing the force vector to be parallel to the bonded interface. A crosshead speed of 0.5 mm/min was applied until the fracture of the specimen. Bond strength was then calculates in megapascals (MPa) by dividing the load at failure recorded in Newtons (N) by the bond area (mm^2).

Failures mode were analyzed by a single operator under stereomicroscope (Kozo Optical and Electronical Instrumental, Nanjing-Jiangsu, China) with 10× mag-

Table 1: Fracture types following the microshear test

Scores	*Fracture type*
1	Adhesive fracture—composite resin/adhesive interface
2	Cohesive fracture in the enamel
3	Cohesive fracture in the composite resin
4	Mixed fracture—composite resin/enamel/adhesive

Table 2: Mean (standard deviation), maximum, and minimum shear bond strength values (MPa)

Experimental group	*MPa*			
	N	*Mean (SD)*	*Maximum*	*Minimum*
G1-WSC	12	8.62 (2.47)	13.40	6.00
G2-WSO	12	7.60 (2.60)	14.00	5.00
G3-WG	12	16.64 (2.36)	22.00	13.00
G4-C	12	13.53 (3.64)	20.00	10.00

Table 3: One-way analysis of variance of the data relative to the shear bond strength

Source of variation	*df*	*SQ*	*QM*	*F*	*p-value*
Bleaching treatment	3	647.7	215.9	27.04	0.0001*
Residual	44	351.3	7.984		
Total	47	999.0			

*p < 0.05

Table 4: Distribution of the scores relative to the fracture types

Experimental group	*Fracture type—Scores (%)*			
	1	*2*	*3*	*4*
G1-WSC	*12 (100)*	*0*	*0*	*0*
G2-WSO	9 (75)	0	3 (25)	0
G3-WG	9 (75)	0	2 (16.66)	1 (8.33)
G4-C	10 (83.33)	0	1 (8.33)	1 (8.33)

nification to investigate the type of fracture, for which purpose the vestibular surfaces were scored as described in Table 1.

STATISTICAL ANALYSIS

The normality of the data was evaluated by the Kolmogorov-Smirnov test. Statistical analysis was performed using one-way ANOVA and the Tukey multiple comparison test (5%) using software PASW Statistics v.17 software, (SPSS Inc, Chicago, USA) and the graph was made using the GraphPad Prism 5 software (GraphPad Software, Inc, San Diego, USA).

RESULTS

The descriptive statistics of the various experimental groups is presented in Table 2 with the bond strength minimum and maximum values.

One-way ANOVA (Table 3) revealed significant difference among the treated groups ($F = 27.04$, $p < 0.0001$). Tukey's post hoc test (5%) demonstrated that the bleached groups exhibited significant difference compared with the control, and the bleached groups in which strips were used (WSC and WSO) exhibited the lowest bond strength values (Fig. 1).

Analysis of the bond strength revealed a predominance of adhesive fractures between the enamel and the composite resin (score 1) in all of the investigated groups. No enamel cohesive fractures (score 2) were observed (Table 4).

DISCUSSION

Tooth bleaching is a widely performed esthetic treatment. Therefore, novel materials and techniques are routinely sought. Due to the easy access to this treatment, the use of whitening strips is widely popular among the options for at-home treatment.[3] Assessment of the composite resin bond following use of bleaching strips revealed a reduction in the bond strength of the restorations. Thus, the null hypothesis of the present study was rejected.

Whitening strips are a simplified at-home bleaching technique that does away with the use of trays. Some *in vivo* studies have assessed the biological safety[9,10] and efficacy of this method.[11,12]

According to Hannig et al[9] more peroxide is released into the saliva when bleaching strips are used compared to trays, however, the salivary flow bears no correlation with the peroxide release by bleaching agents. According to Gerlach et al[10] the currently available bleaching strips result in acceptable concentrations of hydrogen peroxide on the teeth after 60 minutes. Moreover, peroxide is quickly degraded in the gums, and thus the concentration of hydrogen peroxide in the saliva is extremely low during the period of use. In their clinical study, da Costa et al[12] found that the participants preferred at-home bleaching treatment with trays compared with strips.

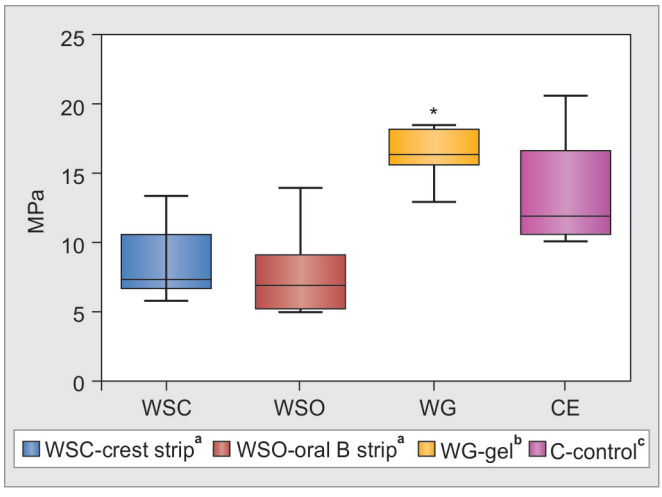

Fig. 1: Tukey's test (5%) mean, standard deviation (MPa) of the bond strength of experimental groups

In vivo studies demonstrate that bleaching strips exhibit promising results after 2 weeks.[11] The clinical study conducted by Mohan et al[13] using 6% hydrogen peroxide reported slight whitening of the teeth after 3 days, whereas significant results appeared after continuous use of the bleaching agent for 14 days.[13]

Bond strength analysis is an important evaluation because in a significant proportion of the cases, whitening and restoration are steps of the same esthetic treatment plan. However, available studies about the influence of bleaching strips on bond strength are scarce.

Considering the tests available to assess the bond strength, the micro-shear test used in the present study is adequate for adhesive restorations,[14] whereas the 'macro' tests exhibit higher rates of enamel cohesive and lower rates of adhesive failures.[15] Studies that assessed the bond strength using micro-shear and microtensile tests reported that the results from micro-shear test seem to be more adequate when the strength of different adhesive systems is evaluated,[16,17] presenting a greater number of adhesive failures.[17]

In the present study, no previous treatment was applied to the teeth vestibular surface, maintaining the aprismatic enamel, which may have impacted the adhesion of materials to the enamel. The present data demonstrate that when restoration was performed after the use of bleaching strips (with 9.5% and 10% hydrogen peroxide), the bond strength decreased. Application of adhesive systems on newly bleached enamel using high-concentration hydrogen peroxide is not recommended because the residual oxygen decreases the polymerization and thus decreases the bond strength of the materials.[18] The bond strength values seem to vary as a function of the bleaching agent concentration,[19] and the available studies do not report the influence of non-tray bleaching agents on the bond strength of resinous materials.

An *in vitro* studies demonstrate that neither at-home whitening strips nor in office bleaching promoted significant structural changes and the hardness and surface roughness remained approximately the same.[20] Conversely, other studies[21,22] reported a significant loss of hardness, increased porosity, and increased surface roughness in the enamel soon after treatment with bleaching agents. These enamel changes also occurred when low concentrations of bleaching agents were used.[22] As a function of the remineralization ability of the saliva, the microhardness levels were restored some time after the end of bleaching treatment.[23]

Götz et al[19] and Mielczarek et al[20] demonstrated that whitening strips with low hydrogen peroxide concentrations do not induce significant changes in the roughness, microhardness, or chemical micro-composition of the enamel surface.

From the at-home bleaching agents analyzed, 7.5% hydrogen peroxide gel (WG) seemed to induce greater bond strength values compared with the whitening strips (WSC and WSO) and the control group (C). The composition of the 7.5% hydrogen peroxide gel includes potassium nitrate, which acts as a desensitizing agent, sodium, and calcium fluoride, which has the purpose of minimizing the sensitivity and the changes on the enamel microhardness.

According to studies, the addition of calcium to bleaching agents for at-home treatment might reduce the enamel susceptibility to erosion,[24] whereas the addition of fluorine and calcium might reduce the mineral loss.[7] Nevertheless, Cavalli et al[7] observed that the bond strength of restorations decreased after whitening treatment, even when fluorine was added to the bleaching agent. Therefore, further studies are needed to elucidate the influence of the addition of potassium nitrate, sodium, and calcium fluoride on the bond strength of resinous materials to the tooth structure.

Analysis of the bond interface revealed that most failures in the investigated groups affected the enamel-resin interface, consistent with the literature.[15,17] The data of the present study corroborate the findings in the literature,[15,17] indicating that most failures in microtests are of the adhesive mode, which ensures bond strength results more appropriate to the dental substrate.

CONCLUSION

Despite the limitations of the present study, it is possible to conclude the following 24 hours after the end of at-home bleaching treatment;

- The whitening strips (WSC and WSO) significantly reduced the bond strength on enamel
- The greatest bond strength values were exhibited by enamel bleached using 7.5% hydrogen peroxide gel with calcium and fluorine (WG)
- On the micro-shear test, most of the failures were adhesive and affected the enamel-resin interface.

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