

The Effect of Bleaching Agents on the Shear Bond Strength of Recently Bonded Restorations to Enamel

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Abstract

Background: Fuji II LC, one type of resin-modified glass ionomer cements, has an excellent bonding efficacy to both enamel and dentin. This material is considered the material of choice for treatment of cervical lesions located along the cements/enamel junction.

Objectives: To evaluate the effect of post-operative bleaching on the shear bond strength of resin-modified glass ionomer cement to enamel.

Methods: Enamel specimens of human molars were bonded with resin-modified glass ionomer (Fuji II LC) and divided into six groups: three control and three bleaching groups. Two bleaching groups were bleached with a 38% hydrogen peroxide either within one hour (B1) or after one week of bonding (B2). The third group (B3) was exposed to a 10% carbamide peroxide bleaching agent for two weeks. Shear bond strength was tested with a universal-testing machine and the data were analyzed by ANOVA test.

Results: A significant difference in Shear bond strength was found between the groups ($p=0.032$). Tukey's test revealed a significant reduction in the shear bonding strength of B3 compared with the control group ($p<0.05$).

Conclusions: Post-operative bleaching with 38% hydrogen peroxide did not compromise bonding efficacy to enamel. However, bleaching with 10% carbamide peroxide reduced bonding strength of resin-modified glass ionomer to enamel significantly.

Keywords: bleaching; resin-modified glass ionomer; shear bond strength.

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Introduction

The demand for aesthetic treatments by patients has increased widely with the whitening of discolored teeth becoming a popular procedure.

Vital bleaching systems using carbamide peroxide (CP) or hydrogen peroxide (HP) can be performed on the external teeth surfaces with high concentrations for in-office procedures or low concentrations for at-home or over-the-counter techniques. When bleaching agents applied onto the tooth surface, hydrogen peroxide is decomposed

into oxygen (O_2) and peroxy radicals (HO_2) [1]. These free radicals penetrate into the dental substrate and react with the dark pigments. This reaction is nonspecific and may cause undesirable effects on teeth and restorative materials [2]. However, with the presence of different systems of bleaching agents, patients need to be aware of the limitations and the hazards of each system. Several hazards have been recognized to be associated with the use of these systems, such as hypersensitivity, enamel demineralization and chemical leakage to the gingiva [3]. If exposed to permeable dentin,

hydrogen peroxide may exert an adverse effect on the cellular metabolism and may pose a risk to the pulpal tissue [4,5]. The need to restore minor cavities such as cervical lesions or repair old fillings with exposed margins before bleaching may be mandatory to reduce the harsh effect of bleaching agents on the exposed tooth surface. However, the effects of bleaching gels on the color match and bonding efficacy of these restorative materials to the enamel may require their replacement. There is a consensus in the literature that replacement of old fillings is a technically demanding, time-consuming procedure, and likely results in weakening of the tooth and renewed insult to the pulp tissue [6]. However, when the position of the fillings is of less importance aesthetically, replacement of such restorations after bleaching may not be necessary if their bonding efficacy is not compromised by the bleaching procedure.

Resin-modified glass ionomers (RMGI) have proven to have the best physical characteristics, in addition to excellent handling properties and all advantages germane to glass ionomers. Their ability to harden rapidly when exposed to a visible light beam make them the most practical to use. Fuji II LC, on the other hand, with its excellent bonding efficacy on enamel and dentin, could be the material of choice for treatment of cervical lesions located along the CEJ or the root surface. Its fluoride ion release is larger than other glass ionomer cements, which may be advantageous for treatment of patients with high caries incidence [7, 8].

Several studies have investigated the effect of bleaching agents on the dye penetration through restorations and their margins both before and after bleaching. Controversy continues regarding the influence of postoperative external bleaching on the microleakage of different bonded restorations. However, reliable bond strength

between enamel and resin can serve to retain the restoration in place and help to resist the forces of polymerization shrinkage and hence microleakage [9]. Up to date, no data is available on the effect of different bleaching systems on the shear bonding strengths of recently bonded restorative materials with resin-modified glass ionomer to enamel. Therefore, the purpose of this study was to evaluate the effect of two kinds of bleaching systems (10% CP and 38% HP) on shear bonding strength (SBS) of resin-modified glass ionomer cement bonded to enamel and bleached in different timing.

Materials and Methods

A total of 48 buccal or lingual specimens from human molars were selected and arbitrary divided into six groups of eight samples each. The specimens were placed inside a PVC matrix with the intended surface facing upward at the same level as the upper rim of the matrix. Acrylic resin was poured around the teeth specimens, with no resin contaminating the selected enamel surface. Flat enamel bonding sites were prepared by wet grinding with a 600-grit silicon carbide paper.

The bonding procedure was performed with resin-modified glass ionomer by applying GC cavity conditioner (GC Fuji Plus conditioner, GC Corporation, Tokyo, Japan) to the flat enamel surface for 10 seconds using a cotton pellet, followed by rinsing and gentle air blowing. Resin-modified glass ionomer cement, GC Fuji II LC (GC Corporation, Tokyo, Japan) was mixed as recommended by the manufacturer and placed into a translucent plastic cylinder with an inner diameter of 2.80 ± 0.03 mm and a height of 3 mm in two incremental layers. Each layer was light-cured for 20 seconds with the same light-emitted diode unit.

Bleaching procedure: After bonding, two bleaching groups (B1 and B2) were bleached using a 38% hydrogen peroxide in-office

bleaching agent (Opalescence Boost, Ultradent Products Inc, South Jordan, UT, USA), following the manufacturer's instructions. B1 was bleached within one hour immediately after bonding while B2 was stored in artificial saliva for one week before bleaching. The bleaching gel was applied on the enamel surfaces and around the bonding sites in a layer of about 0.5-1 mm. A total of 30 minutes of bleaching treatment was carried out in two applications of 15 minutes each. The specimens were then stored in 250 ml of artificial saliva for 24 hours before the shear bonding test was carried out.

The third bleaching group (B3) was bleached with Opalescence PF bleaching gel (Ultradent Products Inc, South Jordan, UT, USA), a commercially available home bleaching system containing 10% CP. The bleaching gel was applied on the enamel surface and around the bonding sites 6 h/day for 14 consecutive days. After bleaching, all the specimens were thoroughly rinsed in running water and stored in 250 ml of artificial saliva for the rest of the day.

The three control groups were stored in the artificial saliva until the shear bonding test was performed in accordance with their respective bleaching groups.

Measurement of Shear Bond Strength: Eight specimens per group were tested in the shear mode using an Instron universal testing machine (Type 8841, Instron Corp., Canton, MA, USA) with a shear knife-edge testing apparatus. The specimens were placed in a holding vice so that the loading head was perpendicular to the bonded cylinder. The test was performed at a cross head speed of 1.0 mm/min. The cross-sectional area at the site of fracture was measured to the nearest 0.01 mm with a digital caliper (Mahr 16ES, Carl Mahr, Esslinger, Germany).

Shear bond strength values in MPa were calculated from the peak load at failure divided by the specimen surface area. One-

way ANOVA was used to analyze the mean bond strengths between the control and bleaching groups. All analyses were processed using SPSS 13.0 software (SPSS, Chicago, IL, USA) at the 5% significance level.

Failure Mode Analysis

After the shear bond strength tests, the modes of bond failure on the enamel surface were observed with a stereomicroscope at 20× magnification. The modes of bond failure were classified as: adhesive (A) if more than 75% appeared to be clean enamel; cohesive in resin (CR) if more than 75% covered with remnants of resin composite; cohesive in enamel (CE) if a portion of the tooth was removed with the material; and mixed failure (M) if between 25% and 75% of the failure was both adhesive and cohesive.

Results

Mean of bond strengths, standard deviation, minimum, and maximum values for all groups are presented in Table 1. One way ANOVA and Tukey's test revealed that there were significant differences between the bleaching and control groups ($p=0.032$). Significant differences were seen between B3 and C1, C2, and C3 ($p=0.021$, $p=0.003$, $p=0.004$, respectively), while no significant differences were seen between C1 and B1 or between C2 and B2 ($p>0.05$). The mean shear bond strengths for C1, C2, and C3 were: 11.68, 13.74, and 13.03 MPa, respectively; while for B1, B2, and B3 were 10.44, 9.93, and 5.94 MPa, respectively.

Figure 1 illustrates the modes of bond failure for all groups. Kruskal-Wallis test showed no significant difference among all groups ($p=0.942$). The control groups showed almost equal modes of mixed and cohesive in resin with few adhesive failures. However, more adhesive failures were seen within the bleaching groups particularly in group B3.

Table (1): Mean, standard deviation (SD), minimum (Min), and maximum (Max) values of SBS for the groups of resin-modified glass ionomer.

Group	Mean * (MPa)	SD	Min	Max
C1	11.68a	4.35	5.69	17.54
C2	13.74b	3.45	9.36	17.76
C3	13.04c	4.41	7.72	18.78
B1	10.44	4.03	5.88	15.54
B2	9.93	3.08	5.77	13.67
B3	5.94abc	2.96	3.94	8.64

* Values with same letter are significantly different at $p < 0.05$.

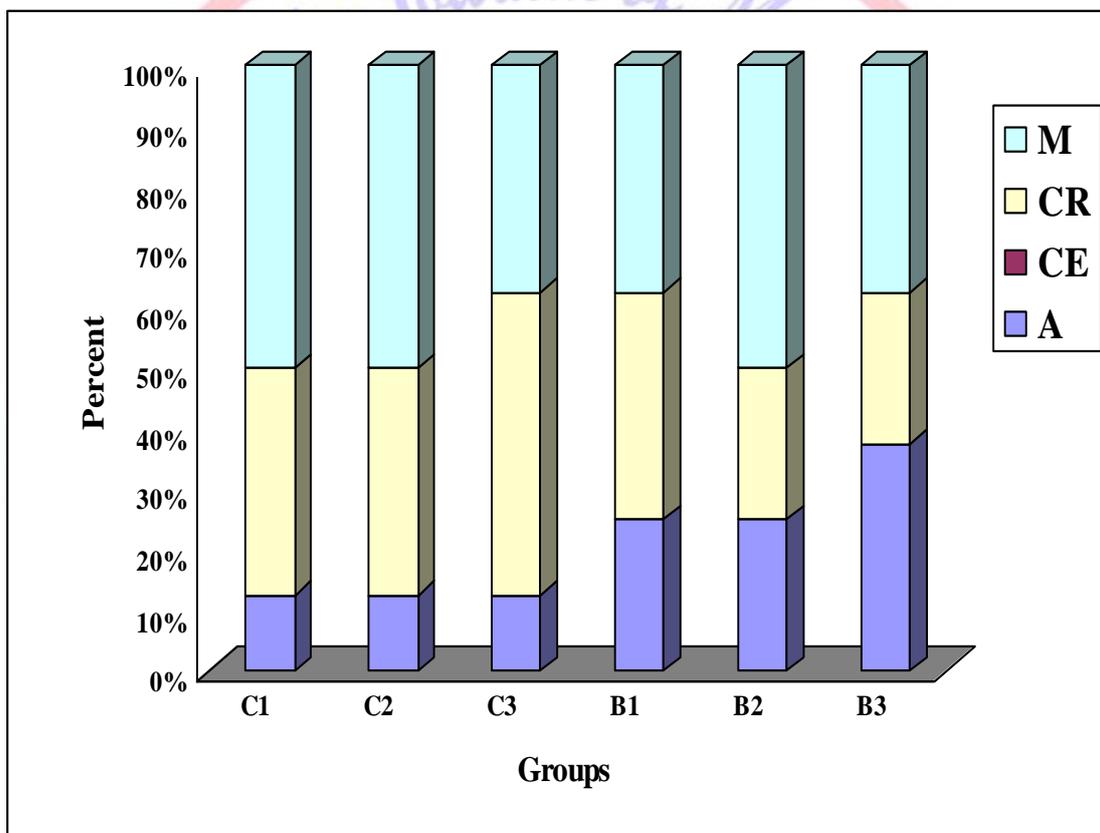


Figure (1): Distribution of modes of bond failure for the groups of resin-modified glass ionomer.

Adhesive (A) if more than 75% appeared to be clean enamel; cohesive in resin (CR) if more than 75% covered with remnants of resin composite; cohesive in enamel (CE) if a portion of the tooth was removed with the material; and mixed failure (M) if between 25% and 75% of the failure was both adhesive and cohesive.

Discussion

The results of the current study showed that post-operative bleaching with 38% HP, did not affect the bonding strength of resin-modified glass ionomer to enamel and that immediate or delayed bleaching procedure did not have an adverse effect on the bonding efficacy. However, bleaching with 10% CP

produced a significant reduction on the SBS of resin-modified glass ionomer to enamel.

Few studies have investigated the effect of different bleaching agents on the microleakage of Class V restorations: Khoroushi and Fardashtaki (2009) who used 30%-35% HP [10]. Moosavi *et al.* (2009) who used 15% CP [11] and Yu *et al.* (2010) was used 10% CP Opalescence PF [12]. Khoroushi & Fardashtaki (2009) showed that in-office bleaching agents with high concentration of hydrogen peroxide in combination with plasma arc light activation could not significantly affect the microleakage of the used resin-modified glass ionomer. They proposed that with the use of reliable bonding agents and with the presence of an efficient bonding between the dental structure and the restorative material, the margins could be safe from the risk of peroxide penetration. Such a result is in accordance with the results of the current study using 38% HP. However, Moosavi *et al.* (2009) was used 15% CP [11] and Yu *et al.* (2010) was used 10% CP reported that post-operative bleaching could increase microleakage of Fuji II LC mostly in the enamel margins and hence is not suitable as a filling material before bleaching. Such results coincide with our results since a significant reduction in bonding strength was recorded with the use of 10% CP [12].

The effects of bleaching agents on dental hard tissues and on the restorative materials have been widely investigated in the literature. Controversial results have been reported on the effect of different bleaching agents on the physical and chemical prosperities of human enamel. High concentration of HP, low pH value and the frequency of exposure to the low pH bleaching agents seem to produce more effect on the enamel surface [13]. Hence, better comparison can be adopted only with studies using similar bleaching agents and study protocols. Two recent studies used 38% HP

(Opalescence Boost) revealed that such an agent can produce no detrimental effect on bleached enamel micromorphology [14] nor produce any severe alterations on the enamel surface [15]. On the other hand, carbamide peroxide-containing agents have been reported to affect the mineral content and organic phase of the superficial layer as well as the inner structure of the enamel [16,17,18]. Such an effect could result in changes in the mechanical properties of enamel such as fracture toughness, leading to a decrease in its bonding strength. However, other studies have demonstrated no significant changes can be found in the chemical composition of enamel surface when using CP bleaching agents [19, 20].

The in-office bleaching system used in this study (Opalescence Boost) although has a high concentration of hydrogen peroxide but with a neutral pH of 7 and contains 1.1% fluoride. Such a pH is not critical for hydroxyapatite demineralization. In addition, the application time was relatively short. On the other hand, the at-home bleaching agent used in the present study, (10% carbamide peroxide, Opalescence PF), contains 0.11% fluoride ion and potassium nitrate with a near-neutral pH of 6.5. The presence of fluoride in the bleaching gel and the use of artificial saliva could both impair demineralization and promote remineralization. Therefore, changes observed after vital bleaching may depend on the composition of the applied bleaching product and its pH-value [21].

Researchers have stated that bonding of composite resins to enamel is improved with a lower incidence of adhesive failures can be achieved with the use of phosphoric acid conditioning or the use of polyacrylic acid conditioning [22]. However, following vital bleaching, over 70 to 80% of bonds have been reported to fail adhesively at the enamel-adhesive and adhesive-composite interfaces [22, 23]. The presence of a high

percentage of mixed failure indicates an adequate interaction of the adhesive system with the substrate [24]. In the current study, more adhesive failures were seen within the bleaching groups particularly in those bleached with 10% CP. Such a result raises a doubt on the efficacy of bonding of resin-modified glass ionomer to enamel after bleaching. However, it has been reported that no bond strength and failure mode standardization can be observed, and that there is no correlation between the failure mode and the bond strength value [25].

Further *in vivo* and/or *in situ* investigations are required to explore the effect of different concentrations of bleaching systems on the bonding strength and microleakage of recently bonded adhesive materials to enamel as well as to dentin. In conclusions Post operative bleaching with 38% hydrogen peroxide after bonding of enamel with Fuji II LC resin-modified glass ionomer did not affect its bonding strength. Resin-enamel bonding efficacy was reliable after bleaching with 38% hydrogen peroxide weather immediately or after 24 hours of bonding. And Bleaching with 10% carbamide peroxide produced a negative influence on bonding efficacy of resin-modified glass ionomer to enamel.

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