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THE EFFECT OF CARBAMIDE PEROXIDE BLEACHING GEL WITH AND WITHOUT REMINERALIZING AGENTS ON MICROTENSILE BOND STRENGTH OF RESIN COMPOSITES TO ENAMEL

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ABSTRACT

Introduction: Carbamide peroxide bleaching gel, along with remineralizing agents, can induce changes in the structure and mineral content of enamel, potentially leading to a decrease in the bond strength of resin composite to the enamel. Therefore, this laboratory study aimed to determine the effect of carbamide peroxide bleaching gel with and without remineralizing agents on the microtensile bond strength (µTBS) of resin composites with microhybrid and nanofill structures to enamel.

Materials and Methods: Thirty extracted third molar teeth were randomly divided into five groups, each group subdivided into two equal subgroups: Group 1: Control group, Group 2: Bleaching gel without fluoride, Group 3: Bleaching gel containing fluoride, Group 4: Bleaching gel containing CPP-ACP, and Group 5: Bleaching gel containing fluoride and CPP-ACP. In the first subgroups, nanofilled resin composite Filtek Z350, while in the second subgroups, microhybrid resin composite Filtek Z250 were bonded to enamel surface. After specimen preparation, µTBS was measured using a universal testing machine. Data were analyzed using parametric tests (P value<0.05).

Results: The highest µTBS of resin composite to enamel was observed in the control group, while the lowest bond strength was seen in the fluoride-containing bleaching group. Comparisons of µTBS between the study groups pairwise, except for the comparison between the control group and the bleaching group, the bleaching group with (CPP-ACP+Fluoride), and the (CPP-ACP) group with the fluoride group, showed significant differences in bond strength. Although, the mean µTBS of the Filtek Z250 composite was higher than the Filtek Z350 composite in all groups, but this difference was not statistically significant.

Conclusion: The use of carbamide peroxide bleaching gel with remineralizing agents leads to a decrease in µTBS of the resin composite to the enamel.

KEYWORDS: Carbamide peroxide bleaching gel, Remineralizing agents, microtensile bond strength, Nanofill composite, Microhybrid composite

INTRODUCTION

As the desire to enhance dental aesthetics grows, teeth whitening (bleaching) has been become a prevalent clinical procedure [1]. It's viewed as an effective and safe method for attaining a radiant smile, available both in the office and for home use. However, there are concerns that whitening natural teeth could potentially compromise enamel integrity [2]. Hydrogen peroxide and carbamide peroxide are among the most commonly used agents for whitening natural teeth [3]. Typically, in at-home bleaching, 10% carbamide peroxide is more frequently utilized. During the bleaching process, 10% carbamide peroxide converts to 3% hydrogen peroxide and 7% urea, accompanied by the release of free oxygen radicals, which play a significant role in the teeth whitening process [4]. The exact mechanism of action of bleaching agents is not fully understood; however, it has been determined that this process occurs through complex oxidation reactions facilitated by free oxygen radicals. These radicals have low molecular weight and can penetrate enamel and dentin, aiding in the whitening process [5]. Numerous investigations have assessed the impact of peroxide-containing products on the physical and chemical characteristics of enamel, yielding conflicting outcomes. Some studies have failed to detect alterations in enamel hardness and morphology following bleaching [6, 7]. Conversely, reports have indicated surface softening, mineral loss, heightened susceptibility to erosion or decay, and diminished resistance to failure post-bleaching [8].

Presently, fluoride compounds are being incorporated into bleaching gels to mitigate potential damage [8]. The topical application of fluoride is known for its effectiveness in remineralization and prevention of demineralization. Fluoride compounds have the capability to repair microstructural defects in teeth induced by bleaching by absorbing and precipitating salivary components like calcium and phosphate [9]. Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP) is a bioactive compound derived from milk products. It is specifically employed to address hypomineralized enamel defects and facilitate the mineralization of primary caries lesions. The CPP-ACP plays a crucial role in maintaining enamel's mineral substance supersaturation, thereby reducing its demineralization rate and enhancing remineralization. This process involves the movement of calcium and phosphate through CPP, penetrating enamel prisms, and reshaping apatite crystals [10]. Numerous in vitro and animal studies have underscored the robust anticarcinogenic potential of CPP-ACP-based compounds [11-13]. Furthermore, when combined with fluoride toothpaste, CPP-ACP has demonstrated increased remineralization efficacy [14]. Experimental evidence suggests that combining fluoride with the CPP-ACP complex induces significantly higher levels of remineralization compared to CPP-ACP and fluoride alone [15]. However, enamel remineralized by CPP-ACP and fluoride exhibits acid resistance, potentially diminishing the bond strength of composite resins [16, 17]. This underscores the adverse impact of pre-treatment fluoride on resin bonding [18].

Bleaching enamel immediately before applying bonding systems can compromise the bond strength of restorative materials. Therefore, it is advised to postpone any restorative procedures for 24 hours to four weeks after bleaching [19, 20]. While various studies have investigated the use of remineralizing agents such as fluoride and CPP-ACP in conjunction with the bleaching process, there has been no research conducted on their effects on the quality of composite resin bonding. Considering the growing demand for cosmetic dentistry and the frequent combination of bleaching with restorative treatments, it is crucial to introduce composites with acceptable mechanical properties alongside addressing aesthetic concerns [21-23]. Hence, the present study also compares the strength of micro-hybrid and nanofill composite resins to enamel after bleaching.

MATERIALS AND METHODS

In this laboratory study, 30 healthy human third molars without any decay or cracks were selected. Any debris on them was removed, and they were kept in a physiological saline solution until the time of testing at room temperature. The enamel surfaces needed for creating standard enamel specimens measuring 4×4 millimeters were prepared by trimming the buccal surfaces with fine-grit diamond disks (Horico-PFINGST, New Jersey, USA). The enamel surfaces were then washed, smoothed, and leveled using aluminum oxide abrasive papers (300 to 600 grit, FEPA-P, Struers, Ballerup, Denmark) and water. All enamel surfaces were examined using a stereomicroscope SMZ 1500 (Nikon, Tokyo, Japan), and samples without any cracks or defects were chosen. The samples were randomly divided into five groups (Table 1).

Table 1 *(Summarizing the experimental groups.)*

Groups	Treatment
1 (Control)	Placed in physiological saline solution at 37°C for 2 weeks, with daily solution changes
2	Exposed to 10% Opalescence bleaching gel (without fluoride)
3	Exposed to 10% Opalescence PF bleaching gel (with 11% fluoride)
4	Exposed to 10% Opalescence bleaching gel (without fluoride), then treated with CPP-ACP paste
5	Exposed to 10% Opalescence PF bleaching gel (with 11% fluoride), then treated with CPP-ACP paste

Samples from groups two to five underwent exposure to the gel for two weeks, with eight hours of exposure each day, followed by rinsing with water for one minute to eliminate the bleaching agent. Additionally, samples from groups four and five were subjected to CPP-ACP paste for an additional two hours post-bleaching, then rinsed with water for one minute. These samples were then kept in physiological saline solution at 37°C until the subsequent bleaching session. Following two weeks of bleaching, the samples were stored in physiological saline solution for an additional two weeks. Afterwards, the enamel surfaces of all groups were etched with 35% phosphoric acid (3M, ESPE, St. Paul, MN, USA) for 30 seconds, rinsed, and dried. Subsequently, Adper Single Bond (3M, ESPE) was applied to the enamel surface according to the manufacturer's instructions and cured for 20 seconds. Then the samples in each group were divided into two equal subgroups.

In the first subgroups, teeth were restored with nanofilled composite Filtek Z350 (3M, ESPE), and in the second subgroups, microhybrid resin composite Filtek Z250 (3M, ESPE) was applied in two layers to a height of five millimeters on the enamel surface. Each layer was cured for 40 seconds using a LED light-curing device (Demetron A.2, Kerr Italia, S.p.A., Scafati, Italy). The prepared samples were stored in distilled water at 37°C for 24 hours, then sectioned using a metallographic cutting machine SYJ-200 (Shengda Machinery Co, Beijing, China), resulting in 12 smaller pieces with a cross-sectional area of one square millimeter for each group. To measure the microtensile bond strength (μTBS), each specimen was first attached to a movable jig using cyanoacrylate adhesive Zapit (Dental Ventures of America Inc, CA, USA), then tested using a universal testing machine (Zwick GmbH & Co, Ulm, Germany) at a speed of one millimeter per minute. The force at the moment of sample fracture was recorded, and the µTBS was calculated by dividing the force applied to the resin composite cylinder's cross-sectional area, reported in megapascals (MPa). Also, the fracture patterns of the samples were determined by one person and examined under a stereomicroscope at 80x magnification. The types of sample fractures were divided into three categories: 1) Adhesive (between adhesive and enamel), 2) Cohesive (within enamel or composite), and 3) Mixed (a combination of both adhesive and cohesive fractures).

For data analysis, SPSS version 21 software was used. The distribution of the data was found to be normal using the Kolmogorov-Smirnov test (P = 0.20), while the homogeneity of variances was not confirmed by the Levene test (P = 0.019). Therefore, one-way analysis of variance (ANOVA) and Tamhane's T2 test were used to compare between groups. Additionally, descriptive statistics (mean and standard deviation) were reported, and the fracture pattern of samples, if applicable, was presented as a percentage. A significance level of $P<0.05$ was considered statistically significant.

RESULTS

The ANOVA revealed a significant difference in the µTBS of the resin-to-enamel composite among the examined groups ($p = 0.001$). According to the findings of this study, the highest µTBS of resin composite to enamel was observed in the control group, while the lowest µTBS was observed in the fluoride group. Additionally, the mean µTBS of the Filtek Z250 composite was higher than that of the Filtek Z350 composite in all groups. However, the results indicated that this difference was not statistically significant ($p>0.05$). Table 2 illustrates the mean and standard µTBS of the resin-to-enamel composite.

Table 2 *(Mean and standard deviation of µTBS of resin composite to enamel.)*

Groups	**Mean±Standard Deviation**	**Maximum-Minimum**
Control	22.83±2.58	27.10±18.10
(Z250)	23.45±2.80	27.10±18.10
(Z350)	22.20±2.30	26.01±19.50
Bleaching	20.43±2.13	25.00±16.20
(Z250)	21.08±2.75	25.00±16.20
(Z350)	19.78±1.06	21.20±18.30
Fluoride	14.64±2.62	19.30±10.10
(Z250)	15.67±2.16	19.30±13.20
(Z350)	13.61±2.74	18.10±10.10
CCP-ACP	16.37±1.80	20.20±13.90
(Z250)	17.35±1.54	20.20±15.00
(Z350)	15.38±1.51	18.40±13.90
CCP-ACP+Fluoride	20.13±1.84	24.00±16.40
(Z250)	20.76±2.30	24.00±16.40
(Z350)	19.51±9.8	20.90±17.90

Tamhane's T2 test (Table 3) showed that the difference in µTBS between the control group and the bleaching group, the bleaching group and the CCP-ACP+Fluoride group, and the CCP-ACP group and the fluoride group was not significant ($p>0.05$). However, the difference in μTBS of resin composite to enamel among the other groups was significant ($p<0.05$).

Table 3 *(Comparison of μTBS of resin composite to enamel between different groups.)*

Intergroup comparison	**p-Value**
Control group with CCP-ACP group	$p<0.05$
Control group with Bleaching group	$p>0.05$
Control group with Fluoride group	$p<0.05$
Control group with CCP-ACP+Fluoride group	$p<0.05$
Bleaching group with Fluoride group	$p<0.05$
Bleaching group with CCP-ACP group	$p<0.05$
Bleaching group with CCP-ACP+Fluoride group	$p>0.05$
CCP-ACP group with Fluoride group	$p>0.05$
CCP-ACP group with CCP-ACP+Fluoride group	$p<0.05$

The fracture pattern of the resin composite bond to enamel in all groups except the control group was predominantly adhesive, whereas this fracture pattern in the fluoride group was more compared to the other groups (Table 4).

Table 4 *(The number (present) fracture pattern of resin composite bond to enamel.)*

Groups	**Fracture pattern**			**Number**
	Adhesive	***Cohesive***	***Mixed***	
Control	7(35)	10(50)	3(15)	20
(Z250)	4(40)	5(50)	1(10)	10
(Z350)	3	5	2	10
Bleaching	9	7	5	20
(Z250)	4	4	2	10
(Z350)	5	3	2	10
Fluoride	11	6	3	20
(Z250)	4	4	2	10
(Z350)	7	2	1	10
CCP-ACP	9	6	5	20
(Z250)	3	4	3	10
(Z350)	6	2	2	10
CCP-ACP+Fluoride	9	7	4	20
(Z250)	5	4	1	10
(Z350)	4	3	3	10

Total	45	36	19	100

DISCUSSION

One of the important needs in cosmetic dentistry is the combination of bleaching treatment with restorative treatments. However, the reduction of enamel microhardness and the decrease in bond strength of resin restorative materials to enamel due to the release of oxygen from bleaching products, which inhibits the polymerization of composite restorative materials, are side effects of bleaching products [24]. In the ongoing process of dental material improvement, changes have also occurred in bleaching materials, including the addition of CPP-ACP and fluoride to their formulation. These changes aim to preserve the mineral content of tooth tissue and reduce tooth sensitivity after bleaching, but they have caused problems in the bonding process of composite restorative materials to tooth tissue, resulting in reduced bond strength due to increased mineral content of tooth tissue [25].

The results of the present study showed that the μTBS in all bleached teeth was significantly lower compared to the control group, with the lowest bond strength observed in teeth treated with fluoride-containing bleaching agent. The highest bond strength was observed in the control group, which did not receive any bleaching treatment. A clinical study reported significantly lower bond strength of one-step total etch bonding to bleached enamel with 15% carbamide peroxide [26]. Chuang and colleagues concluded that bleaching agents cause morphological changes such as porosity and loss of prism shape in enamel, which may weaken the enamel and indirectly reduce bond strength. Although trapped oxygen has been considered the main cause of reduced bond quality, structural defects in enamel also contribute to these changes [27]. Additionally, according to another study, bleaching teeth using 16% carbamide peroxide gel significantly reduced the bond strength of resin bonding restored with phosphoric acid etching [28]. Studies have confirmed that changes in the mineral and protein content of the enamel surface layer following bleaching can be a reason for the reduced bond strength of resin materials to enamel [29, 30]. Furthermore, the bond strength of composite to enamel after bleaching treatment decreases due to reduced resin polymerization [31].

Bleaching materials containing CPP-ACP and fluoride, while reducing tooth sensitivity and preserving the mineral content of enamel tissue, have a negative effect on the bond strength of resin materials to enamel, reducing it [32]. In this study, the greatest reduction in bond strength was observed in teeth treated with fluoride-containing bleaching gel. Fluoride-containing bleaching products compensate for tooth surface hardness more rapidly compared to fluoride-free products and are more resistant to decay attacks. However, fluoride, by depositing calcium fluoride on the enamel surface, increases the resistance of tooth tissue to acid attacks, hindering the desired effect of phosphoric acid and the complete penetration of resin into the tooth tissue, thus resulting in reduced bond strength [33]. Contrary to the present study, some studies have shown that fluoride prophylaxis of enamel prior to orthodontic bracket bonding does not necessarily reduce the bond strength of orthodontic resin bonding [34, 35].

In this study, generally, teeth restored with microhybrid composite Filtek Z250 had higher bond strength compared to those restored with nano-composite Filtek Z350, but this difference was not statistically significant. Andrade and colleagues evaluated the effect of resin composite type (Filtek Z250, Filtek Z350) and bonding system type (Adper Single Bond, Solobond Plus, Futurabond NR) on microleakage and microshear bond strength to enamel, showing that the bond strength of microhybrid resin composite Z250 Filtek was higher when using each of the bonding systems compared to nano-composite Z350 Filtek [36]. In Nassoohi's study, which investigated the effect of composite type (nano-filled, nano-hybrid, and microhybrid) and surface treatment type on microleakage bond strength of composite to enamel, it was demonstrated that the microshear bond strength of microhybrid composite (Filtek Z250) was higher when using each of the treatment surfaces compared to the other two composites [37].

In the present study, it was found that the adhesive bond failure pattern predominates in all groups except the control group, with this failure pattern being more prevalent in the fluoride-containing bleaching group compared to other groups. This could be due to weaker adhesion of the adhesive to the substrate as a result of greater changes in the mineral content of the enamel surface layer compared to other groups. According to the study by Chuang and colleagues, the adhesive bond failure pattern in the bleaching and fluoride-containing bleaching groups was significantly higher compared to the control group. When examining the fracture patterns with electron microscopy, scattered distribution of bubbles and microcavities in the bonding layer in the adhesive failure pattern was observed, and in some groups, interprismatic porosities in the enamel were also observed [27]. In a study conducted by Borges et.al [38], it was observed that the adhesive bond failure pattern in the bleaching group was much higher compared to the control group, while in the control group, a greater proportion of the failure pattern was cohesive and mixed. They concluded, upon examination with electron microscopy, that resin tags of the adhesive penetrated into the enamel [38].

The results of the present study indicate that 10% carbamide peroxide bleaching agents reduce the μTBS of resin composite to enamel. Additionally, the use of remineralizing agents, especially fluoride, along with bleaching, further decreases the bond strength. Teeth restored with microhybrid composite Filtek Z250 exhibited higher μTBS compared to nano-composite Filtek Z350, but this difference was not statistically significant. Furthermore, the predominant adhesive bond failure pattern in all groups was adhesive, with this pattern being more prevalent in the fluoride-containing bleaching group compared to other groups. Since bond strength alone is not a complete criterion for predicting the clinical behavior of dental materials, it is recommended to perform microleakage testing in teeth treated with bleaching agents. It is also recommended that in cases where bleaching is performed before bonding restorations to enamel, a minimum interval of two weeks between the completion of bleaching and the bonding procedure be given to minimize trapped oxygen in the tooth structure.

CONCLUSION

In this laboratory study, the effect of carbamide peroxide bleaching gel, with and without remineralizing agents, on the μTBS of resin composites to enamel was investigated. The results demonstrated that the use of bleaching gel, particularly with fluoride, led to a decrease in bond strength compared to the control group. Additionally, comparisons between different bleaching gel formulations revealed significant differences in bond strength, indicating varying effects based on the presence of remineralizing agents. These findings underscore the importance of considering the impact of bleaching agents and remineralizing agents on the bond strength of resin composites to enamel in clinical practice.

Conflict of Interest:

There is no conflict of interests in this research.

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