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Effect of Different Bleaching Techniques on Microleakage under orthodontic Brackets: In Vitro Study

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Abstract

Statement of problem: Numerous studies report significant changes in tooth color that occur during orthodontic treatment. The adverse effects of bleaching procedures during orthodontic treatments have not been studied comprehensively.

Objectives: This study investigated the effects of two methods of dental bleaching on the degree of microleakage beneath orthodontic brackets.

Materials and Methods: We selected 45 extracted premolar teeth and bonded them to orthodontic brackets. These teeth were stored in normal saline for 24 hours and thermocycled. We randomly divided the samples into 3 groups of 15 teeth per group. The first group (control) received no bleach treatment; the second group (office bleaching) was treated with 35% hydrogen peroxide (Whiteness HP Maxx); and the third group (home bleaching) was treated with 22% carbamide peroxide (Whiteness Perfect). The apices were sealed with sticky wax, rinsed in tap water, and air-dried. We applied nail varnish to the entire surface of each tooth, except for an area approximately 1 mm away from the brackets. The samples were immersed in basic fuchsine and cleaned after 24 hours. Microleakage was determined by direct measurement using a stereomicroscope. Kruskal-Wallis and Dunn post-hoc statistical tests, and SPSS software were used for statistical analysis. The significance level was set at $P \leq 0.05$.

Results: The office bleaching group had significantly more microleakage scores under the brackets at both the occlusal (P=0.04) and gingival (P =0.040) margins of the brackets compared to the home bleaching group. The home bleaching group showed statistically more significant microleakage scores than the control group in both the gingival (P=0.006) and occlusal (P=0.014) margins of the brackets. All three groups had statistically more significant microleakage at the gingival margins of the brackets than the occlusal margins.

Conclusions: Office bleaching caused the most microleakage under the brackets and home bleaching caused more microleakage than the control group. We observed more microleakage at the gingival margins of the brackets compared to the occlusal margins.

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Introduction

Tooth bleaching is considered the first option to improve tooth color since it is a minimally invasive approach with acceptable esthetic results compared with other esthetic procedures such as crowns or veneers [1]. Dental bleaching can be performed directly by the dentist in a clinic (in-office bleaching), by the patient at home with professional supervision (in-home bleaching), or without professional supervision with over-the-counter products (over-the-counter). Many studies have reported that significant tooth color changes could occur during orthodontic treatment [2-4]. Fixed orthodontic treatment, particularly in young patients, provokes greater accumulation of plaque and stain deposition on teeth surfaces [5]. Currently, many orthodontic patients request tooth whitening procedures [6]. However, ideal tooth whitening should be performed after the removal of brackets at the end of orthodontic treatment [7]. Dental professionals presume that a bleaching procedure during orthodontic treatment is not possible because of the presence of the brackets, which interferes with peroxide diffusion into the labial surfaces of the teeth [8, 9]. The whitening treatment is usually performed after orthodontic treatment when bracket removal would permit bleaching agents to have better access and function on the facial surfaces of the teeth. The mechanism of the dental bleaching agent is a redox reaction that releases active oxygen, which diffuses through the tooth structure. Owing to its low molecular weight, hydrogen peroxide reduces the organic pigments that impregnate in enamel groves and dentin, and consequently leads to their elimination [10]. Studies [5, 7, 9] have evaluated the effectiveness of bleaching treatments during orthodontic treatment. However, there is limited evidence about the adverse effects of bleaching procedures during these treatments, such as the effects on the enamel-adhesive bond under the brackets. A number of reports have discussed the interaction between bleaching agent and bond efficacy of composite resins or orthodontic adhesives to bleached enamel. The authors reported a substantial reduction in the bond strength of the composite resin to bleached enamel compared to unbleached enamel [11-13]. Some studies concluded that residual peroxide or oxygen on the tooth structure might be responsible for the decrease in bond strength [14]. The enamel acts as a semipermeable membrane. It has been concluded that the bleaching agent and by-products that result from its decomposition are able to disperse proximally within the tooth structure, even at the presence of a fixed orthodontic appliance [5]. Jadad *et al*. [15] showed the effectiveness of an 8% hydrogen peroxide-based whitening agent in cases with fixed orthodontic appliances [15]. Arboleda-Lopez *et al*. [7] reported that the bleaching technique was effective and changed the shade of the teeth in the presence and absence of orthodontic brackets. Akin *et al*. [16] found that 10% carbamide peroxide bleaching did not significantly decrease shear bond strength values of orthodontic brackets. Comparably, 38% hydrogen peroxide bleaching significantly reduced these values. Mullins *et al*. [17] stated that brackets bonded within 24 hours following bleaching had a higher possibility for bond failure. Orthodontic bonding should be deferred for 2–3 weeks when patients have a history of in-office bleaching with 38% hydrogen peroxide. These studies evaluated the enamel that was bleached before the bonding procedures, which followed the bleaching procedures. In the abovementioned studies, the enamel under bleaching treatment did not have any bracket, nor was there composite restoration bonded to the enamel. To the best of the authors' knowledge, no study evaluated the effects of bleaching agents on bond strength and microleakage scores on enamel bonded to composite restorations or orthodontic brackets. Microleakage of dental restorative materials is an imperative problem in clinical dentistry [18]. Microleakage can be demarcated as the clinically undetectable dissemination of bacteria, fluids, molecules, or ions between a cavity wall and the restorative material [19]. Microleakage enables the transfer of bacteria from the oral cavity by gap formation [20]. It may cause enamel discoloration, corrosion, decreased bond strength, recurrent caries, and pulpal injury [18, 21]. This in vitro study has investigated the effects of two methods of dental bleaching on the degree of microleakage beneath orthodontic brackets. The null hypothesis advocates that there is an equal degree of microleakage under orthodontic brackets in specimens with and without bleaching procedures.

Materials and Methods

Sample preparation

This in vitro study assessed 45 premolars previously extracted for orthodontic purposes. The samples were intact and did not have any cracks, restoration, white spots, gross irregularities, decays, fractures, previous bracket bonding, or enamel hypoplasia. The teeth were scaled and washed to remove any covered blood, soft tissue, or debris. Next, they were immersed in 10% formalin solution for two weeks for sterilization [22]. The teeth were kept in saline solution at 37ºC for no more than one month. The normal saline was changed weekly to prevent bacterial growth.

Bonding procedure

Before the etching procedure, the buccal surfaces of the teeth were cleaned using fluoride-free pumice paste and a rubber cup in a low-speed hand piece. Next, they were rinsed with water and air-dried. All samples were etched with a 37% phosphoric acid gel (3M Unitek, Monrovia, CA, USA) for 30 seconds. After application of the acid, the buccal surfaces were rinsed thoroughly for 15 seconds and dried with oil- and moisture-free air until a frosty white appearance was achieved. After the etching process, we applied a thin layer of Transbond™ XT primer (3M Unitek, Monrovia, CA, USA) onto the surfaces of the teeth with a brush, light cured with an LED light unit (BlueLEX GT-1200W, San Chong, Taipei County, Taiwan) for 10 seconds. Transbond XT adhesive paste (3m Unitek, Monrovia, CA, USA) was applied to the bracket base (American Orthodontics, MBT, 022, Sheboygan, WI, USA), and the bracket was placed on the FA point on the tooth. The FA point is described as the middle of the clinical crown occluso-gingivally and mesiodistally, following the long axis of the crown. The excessive composite resin was removed with a dental explorer. Each tooth was light-cured for 30 seconds- 15 seconds from the mesial, and 15 seconds from the distal.

Thermocycling

After the bonding procedure, the teeth were stored at room temperature in normal saline for 24 hours. Thermocycling was performed at 5±2°C to 55±2°C for 1000 cycles with a dwell time of 30 seconds and a transfer time of 5 seconds.

Bleaching procedure

We randomly divided the samples into three groups of 15 per group by random selection.

The first group (control) received no bleaching treatment. In the second group (office bleaching), the teeth were bleached with a 35% hydrogen peroxide gel (Whiteness HP Maxx, FGM Dental Products, Joinville, SC, Brazil). In the third group (home bleaching), the teeth were bleached with a 22% carbamide peroxide gel (Whiteness Perfect, FGM Dental Products, Joinville, SC, Brazil). In the second group, we applied the 35% hydrogen peroxide gel to the entire facial surface of the teeth according to the manufacturer's instructions. Three courses of a 15-minute application were performed for each bleaching session for three bleaching sessions, each 45 minutes with no interval. In the home bleach group, we applied a 22% carbamide peroxide gel to the facial surface of the teeth without using a dental tray. The gel remained for one hour on the tooth's surface during each bleaching session. In total, there were 12 bleaching sessions with no interval. In both groups, after each tooth whitening session, the gel was removed, and the surface was washed with tap water and dried with compressed air.

Evaluation of microleakage

The apices were sealed with sticky wax, rinsed in tap water, and air-dried. Then, two layers of nail varnish were applied to the entire surface of the tooth, except for an area approximately 1 mm away from the brackets, which was marked with a black pencil. Next, the samples were immersed for 24 hours at room temperature in a 0.5% solution of basic fuchsine (0.5 g powder in 100 ml of distilled water) that covered the entire teeth and brackets. After 24 hours, the superficial dyes were removed from the samples by a low speed handpiece and bristle brushes. A buccolingual directed cut was made on the midline of the brackets on samples with a low-speed diamond disc (Brasseler, Lemgo, Germany). Next, we used a stereomicroscope (BS 3060, China, 40X magnifications) to record the microleakage scores in millimeters. Microleakage was determined by direct measurement using the image analyzer software of the stereomicroscope (scope image: 9X, magnification: 40x). Half of the samples were randomly re-examined to evaluate for intra-observer error of measurement. Occlusal and gingival margins of the brackets were assessed for leakage scores in the tooth-adhesive interfaces.

Statistical analysis

We used the Kruskal-Wallis and Dunn post-hoc statistical tests, and SPSS software (version 22, Chicago, IL, USA). The significance level was set at $P \leq 0.05$ for all tests.

Results

A comparison of the microleakage scores (mm) for all specimens according to the Kruskal-Wallis test in both the occlusal and gingival margins showed statistically significant differences ($P<0.001$). The bleaching procedures caused increased microleakage scores under the orthodontic brackets. The results of the post-hoc test showed that the office bleaching group had significantly more microleakage scores under the brackets at both the occlusal ($P=0.04$) and gingival ($P=0.040$) margins of the brackets compared to the home bleaching group. The home bleaching group showed statistically more significant microleakage scores than the control group in both the gingival ($P=0.006$) and occlusal ($P=0.014$) margins of the brackets. A comparison of the gingival margins of the brackets to the occlusal margins showed significantly more microleakage in all three groups – office bleaching ($P=0.009$), home bleaching ($P=0.007$), and control ($P=0.049$). One-way ANOVA showed no significant intra-observer differences. Table 1 summarizes the study results. Figure 1 shows the microleakage at the gingival and occlusal sides (magnification: 40X).

Discussion

This study evaluated the effects of bleaching procedures on microleakage at the enamel-adhesive interface from the occlusal and gingival margins of brackets in patients who undergo orthodontic treatments. The enamel surfaces and enamel-adhesive interfaces were treated chemically with the aim to break the adhesion at the composite-enamel interface. The specimens have been subjected to a microleakage test. Orthodontic treatments and bleaching procedures both have the potential to increase the risk of microleakage by affecting the enamel surface and enamel-adhesive interface [23, 24]. Hence, the current study has intended to determine the safety of bleaching teeth during orthodontic treatment. Hydrogen peroxide and carbamide peroxide dissolution products are low molecular-weight molecules that easily diffuse into the lamellae, grooves, fissures, and depression areas in enamel structures [8]. If the bleaching agent spreads through the enamel pores and diffuses into the dentinal tubular structure, so the bleaching

Table 1: Median and Mean±Standard deviation (SD) of microleakage (mm) at the enamel-adhesive interface measured from the occlusal and gingival margins of the bracket base

		Office bleaching	Home bleaching	Control	P-value
Gingival	Mean ± SD	0.34±0.17	0.14±0.11	0.02±0.016	P <0.001
	Median	0.3200	0.1000	0.0200	
Occlusal	Mean ± SD	0.18±0.14	0.05±0.05	0.01±0.01	P <0.001
	Median	0.1100	0.0200	0.0100	

Figure 1: Arrows show microleakage at the gingival and occlusal sides (magnification: 40X)

process can be done in patients with orthodontic devices. Free radicals from hydrogen peroxide can disseminate in all directions throughout dental structures located under the bracket adhesive interface. Therefore, they have the potential to spread through the enamel-adhesive interface and, consequently, affect the resin tags and bond efficacy under the brackets. They may also break the organic stain molecules present throughout the labial surface of the teeth [5]. Several techniques have been introduced to evaluate microleakage in dentistry. The easiest and most frequently used method involves exposure of the samples to a dye solution before viewing cross-sections under a light microscope [25]. We have chosen dye penetration for this study since it provides a simple, relatively inexpensive quantitative and comparable method for evaluation of possible microleakage. To the best of the authors' knowledge, this study was the first that investigated the effect of bleaching on microleakage values of enamel adhesive interface under orthodontic brackets. The results showed that all bleaching procedures adversely affected the bond efficacy of orthodontic brackets to the enamel with increased microleakage scores. However, we observed significantly increased microleakage values among the specimens from the office bleaching group. Hence, this bleaching technique might have the most destructive effects on the enamel- adhesive interface and resin tags. This concern should be considered for patients who request to bleach their teeth during the orthodontic treatments. Patients should be informed that an increased rate of white spots, decalcifications, staining, and numerous other adverse effects would be expected consequent to increased microleakage scores under the brackets. However, if the patient insists on bleaching during orthodontic treatment, home bleaching is the technique of choice due to its apparently less adverse effects. The office bleaching group had more microleakage than the home bleaching group; hence, the impact of bleaching agents on microleakage could be considered to be concentration-dependent. In addition, the influence of the bleaching procedure on the morphology and hardness of the enamel surface depended on the concentrations of the active ingredients [26]. The gingival margin generally exhibited a higher microleakage value compared with the occlusal margin of the enamel-adhesive interfaces. However, the difference was statistically significant for any of the study groups. Several studies [27-30] reported statistically greater microleakage in the gingival rather than the occlusal margins. This finding was attributed to either the surface curvature anatomy which might result in relatively thicker adhesive at the gingival side [27, 29] or to the curing method that emitted light only from the occlusal side [28, 30]. The relatively greater microleakage obtained from gingival enamel probably resulted from its aprismatic structure, which appeared to be more resistant to dissolution in acids compared to the prismatic mid-coronal enamel [31]. It seemed that the difference in microleakage values between gingival and occlusal margins of the brackets was irrelevant for the bleaching procedures and unbleached specimens. The microleakage values in the gingival margin of the brackets were greater than the occlusal margin.m Perhaps, with a larger number of specimens the outcomes could be unequivocally different. Therefore, we suggest that further studies be conducted with larger numbers of samples.

Conclusions

The office bleaching group showed the most microleakage values under the brackets, whereas the home bleaching group had more microleakage compared to the control group. We observed microleakage at the gingival margins of the brackets compared to the occlusal margins.

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Conflict of Interest: None declared

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