Original Article

Effect of In-Office Carbamide Peroxide-Based Tooth Bleaching System on Wear Resistance of Silorane-Based and Methacrylate-Based Dental Composites

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Abstract

Objectives: Several studies have assessed the characteristics and properties of silorane-based composites and adhesive systems. Considering the extensive application of tooth-whitening agents, possible deteriorative effects of tooth bleaching agents on these restorative materials must be studied. The aim of this study was to evaluate the effect of an in-office carbamide peroxide-based tooth bleaching agent on the wear resistance of a silorane-based and a conventional microhybrid dimethyl methacrylate-based dental composite with two different application times.

Materials and Methods: Thirty cylindrical specimens were made of Z250 and P90 dental composite resins (n=15 for each composite). Samples made of each composite were divided into three groups (n=5) for immersion in an in-office bleaching agent (Opalescence® Quick 45%) for either three or eight hours or saline solution (control). Wear tests were conducted after bleaching using a pin-on disk apparatus under the load of 40N at a constant sliding speed of 0.5 ms^{-1} for a sliding distance of 300 m. The samples were weighed before and after the wear test. Repeated measures ANOVA was used to statistically analyze the obtained data (α=0.05).

Results: There was a significant decrease in the weight of samples after the wear test ($P<0.001$). However, no significant difference was found among groups in the mean weight of samples before and after the wear test ($P>0.05$).

Conclusion: Bleaching for three or eight hours using 45% carbamide peroxide had no deteriorative effect on the wear resistance of Z250 and P90 composites.

Keywords: Silorane Composite Resin; Dental Restoration Wear; Tooth Bleaching Agents; Carbamide Peroxide.

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INTRODUCTION

Revolutionary development of dental composites introduced new horizons of esthetics in restorative dentistry. The ability of composite resins to bond directly to tooth structure makes restorative procedures more conservative without removing healthy tissues [1]. Despite the significant improvements of dental materials, methacrylate-based composites still have shortcomings that limit their applications and influence the success of restorations [2]. Recently, a new class of low-shrinkage dental composite resins was introduced based on silorane technology [3].

In silorane-based composites, the silorane resin replaces the methacrylate resin matrix. This substitution provides lower polymerization shrinkage and better hydrolytic stability [3-5].

Various restorative techniques have been introduced for treatment of discolored teeth including direct composite veneers, indirect porcelain veneers and ceramic crowns. Since the 1870s, tooth bleaching has been used to overcome discolorations in selected cases [6].

Hydrogen peroxide and other peroxide releasing agents such as carbamide peroxide are being used for tooth whitening. Several previous studies have assessed the effect of dental bleaching agents on the properties of dental hard tissues [7-10] as well as dental restorative materials [11-13]. Unfortunately, the oxidation effect of peroxide is unspecific and it can react with -C–C- single bonds or -C=C- double bonds, which are abundant in dental polymers [14]. Some previous studies reported a slight, but significant, increase in the surface roughness and porosity of micro-filled and micro-hybrid composite resins after exposure to different bleaching agents [13,15,16]. Although there are some studies reporting that hydrogen peroxide does not reduce the microhardness of composites [6,17], other studies showed a decrease in their surface microhardness [18,19].

Due to the effect of surface hardness on the wear process of materials [20], it seems that the probable softening effect of dental whitening agents on the composite resins may lead to decrease in their wear resistance. Furthermore, increase in the roughness and porosity of the composite surface following the application of bleaching materials has been proven using scanning electron microscopic (SEM) studies and profilometric investigations [13,16], which exhibit the deteriorative effect of this chemical agent on the composite surface. Wear of composite resins is a major issue with regard to the clinical durability of restorations [21]. Mechanical and environmental factors (including chemicals) may influence the failure of restorative materials [20].

In fact, consid-ering the complex biomechanical nature of occlusal forces, variable physical circum-stances and biological intervening factors, study of wear process of dental composites seems to be complicated [22]. Three basic elements have been described affecting the composite wear including structure of the restorative material as well as the environ- mental and situational factors, in which the interactions occur [20].

According to the existing literature, there is not enough information about the influence of tooth bleaching agents on the wear resistance of

Table 1. Properties of materials used in this study

Product	Description	Composition	Manufacturer
Filtek™ Z250	Microhybrid restorative dental composite resin –A2 Shade	Organic matrix: Bis-GMA; UDMA; BisEMA; Initiator: Camphorquinone Filler: Zirconia/silica (60v%)	3M ESPE, St. Paul, MN, USA
Filtek™P90	Low shrinkage dental composite	Organic matrix: Silorane resin Initiator: Camphorquinone, iodonium salt and electron donor Filler: Quartz and yttrium fluoride (76w%)	3M ESPE, St. Paul, MN, USA
Opalescence® Quick 45% PF	In-office bleaching system	Carbamide peroxide (45%)	Ultradent Products Inc., South Jordan, Utah, USA

silorane-based dental composites. Thus, this study sought to evaluate and compare the influence of an in-office carbamide peroxide-based dental bleaching agent on the wear resistance of a silorane-based and a conventional micro-hybrid dimethyl methacrylate-based dental composite with different durations of application.

MATERIALS AND METHODS

Specific properties of two commercially available dental composite resins used in this study are described in Table 1. A custom-made polyethylene split mold was used to prepare cylindrical composite samples. Fifteen samples (height of 7mm and diameter of 5mm) of each composite (P90 and Z250) (Table 1) were fabricated. The mold was filled with composite resin and the excess material was removed using a glass slab placed over the mold before photo-curing (LED light-curing unit; Blue Phase, Ivoclar Vivadent, Liechtenstein, Austria) for 20 seconds with 1200 mW/cm^2 light intensity from the top and the bottom. After separating the two parts of the split mold, the samples were cured for an extra 20 seconds in the middle part laterally. Ten samples of each composite resin were immersed in an in-office bleaching agent (Opalescence® Quick 45%) (Table 1) according to the manufacturer's instructions, for either three or eight hours. Saline solution was used in the control group (n=5 of each composite). Next, the samples were removed from the containers and stored in distilled water for 24 hours (25°C). The weight of each sample was recorded using a digital balance (XP26 Microbalance, Mettler Toledo, Columbus, OH, USA) before the wear test. The wear test was conducted using a pin-on-disk tribometer under a normal load of 40 N at a constant sliding speed of 0.5 ms^{-1} for a sliding distance of 300m. The tribometer was built according to STM G 99. A container was also used to hold the medium in the contact region during the wear test. The composite samples were in contact with the aluminum oxide disks. Slurry of Biotene® mouthwash (Laclede Inc., Rancho Dominguez, CA, USA) was applied to decrease the temperature and simulate the oral conditions. The samples were washed using deionized distilled water and the weight of samples was recorded again after the completion of wear test.

Statistical analysis:

Statistical analysis was performed using repeated measures ANOVA (SPSS version 16, Chicago, IL, USA) to evaluate the effect of exposure time (three hours versus eight hours) of the bleaching agent and the type of composite (as between-subject factors) on the weight of specimens before and after the wear test (α=0.05).

RESULTS

The mean and standard deviation of weight before and after the wear test are reported in Table 2. Repeated measures ANOVA showed that the mean weight decreased significantly after the wear test compared to baseline ($P<0.001$); but there was no significant difference ($P=0.33$) between groups (different types of composites and different exposure times as the between-subject factors) with regard to changes in weight.

DISCUSSION

In the current study, we evaluated the effect of an in-office carbamide peroxide-based tooth bleaching agent on the wear resistance of two different composite resins after two different time periods.

Carbamide peroxide is one of the most widely used bleaching agents, which is supplied in various concentrations with in-office or at-home applications. Carbamide peroxide breaks into hydrogen peroxide (approximately one-third) as the active agent and urea (two-thirds) [23].

Thus, 45% solution of carbamide peroxide used in our study corresponds to approximately 15% hydrogen peroxide. As it has been shown that hydrogen peroxide gel can increase the surface roughness of composite resins, it was suggested that hydrogen peroxide may chemically attack the organic matrix, leading to softening of the material [24]. The softening may be due to the hydrolytic degradation of composites, which may be accelerated due to the effect of the chemical process of bleaching agents [11]. Immersion of dental composite resin in chemicals softens their Bis-GMA matrix copolymer and significantly lowers their wear resistance. Chemicals with solubility parameters similar to those of resin matrix can soften the composite [25].

In the current study, the difference in weight before and after mechanical abrasion was used to describe the wear resistance of two different composite resins after exposure to tooth bleaching agent. After exposure to 45% carbamide peroxide, the two composites showed no significant difference in weight after three or eight hours. Furthermore, no significant difference was observed between bleached and control groups. The significant decrease in weight in each group indicates the role of mechanical rather than chemical wear in all groups. It means that the material loss in all groups was related to the mechanical wear and that the bleaching treatment did not increase the risk of further mechanical wear.

Some previous studies reported that higher concentrations of bleaching agents did not significantly affect the surface microhardness [6,17]. Polydorou et al. reported that 38% hydrogen peroxide did not cause any significant reduction in microhardness of dimethacrylate micro-hybrid and Ormocer-based restorative materials [6].

Similarly, Lima et al. [26] found that 35% hydrogen peroxide did not have a significant effect on the surface microhardness. Sharaffedin and Jamalipour also reported that 35% carbamide peroxide did not reduce the hardness of a microhybrid composite [27].

Due to the close relationship of surface hardness and wear resistance, these studies confirm our findings. On the other hand, some studies [18,19] reported significant effect of carbamide peroxide bleaching agent on the mechanical properties of dental composites (i.e. surface microhardness). However, these findings must be interpreted with caution. First, surface microhardness is an integral factor in the wear process, but all statistically significant effects on surface microhardness may not cause significant clinical outcomes (slight effects may be statistically significant but clinically insignificant) [13,15,16].

Second, inconsistency between the results

Table 2. The mean and standard deviation of weight loss of the two composites with regard to different concentrations of the bleaching agent and duration of exposure

		Mean Weight (SD) mg			
		P90		Z250	
		Before wear test	After wear test	Before wear test	After wear test
Control	3 hours	258.9(6.7)	257.8(6.6)	266.5(10.5)	265.4(10.7)
	8 hours	262.3(5.6)	2613(5.5)	273.0(4.0)	272.3(5.6)
Opalescence® Quick 45% PF	3 hours	260.4(5.1)	259.3(4.8)	265.6(5.9)	263.9(5.7)
	8 hours	269.1(6.0)	267.9(5.8)	267.3(11.1)	265.9(16.3)

obtained by different studies may be due to different composite substrates, as well as the difference in protocols of applications of bleaching materials (i.e. exposure time and concentration). Furthermore, due to the complex nature of wear process, it is not possible to predict the wear resistance of composite restorations only on the basis of their surface hardness.

The current study investigated the effect of 45% carbamide peroxide tooth bleaching agent on the wear resistance of two dental composites. However, further investigations using different types of tooth bleaching products are required for evaluation of topographic changes for clinical applications. Moreover, the pattern and duration of application of abrasive forces in vivo may be different from those in-vitro.

CONCLUSION

Under the limitations of this in-vitro study, it can be concluded that P90 and Z250 composite resins would have the same mechanical wear behavior after exposure to 45% carbamide peroxide tooth bleaching agent.

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