THE EFFECT OF CARBAMIDE PEROXIDE BLEACHING AGENTS ON THE MICROHARDNESS OF DENTAL CERAMICS

Sheila P. Passos, Aleska D. Vanderlei, Susana M. Salazar-Marocho, Sarina M.B. Azevedo, Vanessa Z.C. Vasquez, Estevão T. Kimpara

Department of Dental Materials and Prosthodontics São Paulo State University at São José dos Campos, Brazil.

ABSTRACT

This study examined the effect of 10% and 16% carbamide peroxide bleaching agents on the surface microhardness of micro-particulate feldspathic ceramics (VM7 and VM13, Vita Zahnfabrik). Forty specimens (8-mm diameter, 2-mm thickness) were divided into four groups (n=10): G1- VM7 + 10% Whiteness, G2- VM7 + 16% Whiteness, G3- VM13 + 10% and G4- VM13 + 16% Whiteness. The home-use bleaching agents were applied for 8 hours on 15 days, and the specimens were stored in distilled water at 37°C. The Vickers hardness number (HV) was determined for each specimen. Data were analyzed by the Wilcoxon and Mann-Whitney tests (p<0.05). The microhardness values before exposure were: g1- 433 (57); g2- 486 (22); g3- 509 (28); g4- 518 (24), and after exposure: G1- 349 (32); G2- 496 (95); G3- 519 (38); G4- 502 (81). G2 exhibited a higher and significant difference than G1 in VM7 groups, and the effect of bleaching concentration was shown to be significant by the Mann-Whitney test. And for VM13, both the Wilcoxon and Mann-Whitney tests showed no significant differences. When using 10% carbamide peroxide, the microhardness of VM7 ceramic was affected, and there were no effect on the microhardness between VM7 and VM13 ceramics when 16% carbamide peroxide was used.

Key words: ceramics, hardness, tooth-bleaching agent.

EFEITO DO PERÓXIDO DE CARBAMIDA NA MICRODUREZA SUPERFICIAL DE CERÂMICAS DENTAIS

RESUMO

Este estudo examinou o efeito do agente clareador peróxido de carbamida a 10% e a 16% na microdureza superficial de cerâmicas feldspáticas micro-particuladas (VM7 e VM13, Vita Zahnfabrik). Quarenta corpos-de-prova (8 mm de diâmetro, 2 mm de espessura) foram divididos em quatro grupos (n=10): G1- VM7 + 10% Whiteness, G2- VM7 + 16% Whiteness, G3- VM13 + 10% e G4- VM13 + 16% Whiteness. Os agentes clareadores foram aplicados por 8 horas durante 15 dias e os cp foram armazenados em água destilada a 37°C. A dureza Vickers (HV) de cada cp foi determinada. Os dados foram analisados pelos testes de Wilcoxon e Mann-Whitney (p<0.05). Os valores da dureza antes da exposição ao agente clareador foram: g1- 433 (57); g2- 486 (22); g3- 509 (28); g4- 518 (24), e depois da exposição: G1- 349 (32); G2- 496 (95); G3- 519 (38); G4- 502 (81). G2 exibiu diferença significante e microdureza maior comparado ao G1 nos grupos da VM7 e o efeito da concentração do clareador foi significante, apresentados através dos testes Mann-Whitney. Para VM13, ambos testes, Wilcoxon e Mann-Whitney, não apresentaram diferença significante. Quando o peróxido de carbamida a 10% foi avaliado, a microdureza da cerâmica VM7 foi afetada, e não houve diferença na microdureza entre as cerâmicas VM7 e VM13 quando o peróxido de carbamida a 16% foi utilizado.

Palavras chave: cerâmicas; dureza; agentes clareadores.

INTRODUCTION

Dental bleaching has been one of the most sought-after treatments in restorative dentistry, because it is considered a conservative alternative for recovering esthetic characteristics. For brightening discolored teeth, the use of hydrogen peroxide or peroxide releasing agents, such as carbamide peroxide or sodium perborate, has been a popular treatment[1]. The bleaching agents available are usually based on 6-20% and 25-40% peroxide gels for home and in-office whitening, respectively[2].

Carbamide peroxide solutions immediately dissociate on contact with tissue or saliva[3] into hydrogen peroxide and urea. These products degrade into oxygen and water, and into ammonia and carbon dioxide, respectively[4]. For home treatment, bleaching times depend on the length of time per day that the patient applies the bleaching solution.[3] On the other hand, in-office bleaching uses higher-concentration solutions applied for shorter periods of time, since these products are capable of producing more peroxide radicals, hence accelerating the process[5].

The effects of the bleaching agents may result in changes in physical properties, surface morphology, and color of different restorative materials, and these effects have been investigated in several *in vitro* studies, simulating the clinical situation as closely as possible[1]. Thus, it would be impossible for bleaching agents to remain in the oral environment, because they may reduce microhardness of dental enamel [6-8], the main reasons for this reduction being the effect of the peroxide on the organic matrix of the enamel and the action of the bleaching agents present in the gels.

Tooth bleaching is not believed to create macroscopically visible defects, but microscopic alterations could themselves cause undesirable effects.[2] Several studies have assessed the effects of peroxide carbamide, such as microstructural changes and decreased hardness[5,9], on dental restorative materials[4,9,11,12]. Furthermore, it has been observed that 10% carbamide peroxide reduced the microhardness of feldspathic dental ceramics[9]. However, the authors found no study of the effect of carbamide peroxide on the surface texture of dental ceramics. Some studies have demonstrated that there was no significant difference in the effect of the bleaching agents on any restorative material[3,4,13,14].

Few studies have been conducted on the effects of this agent on the microhardness of various esthetic restorative dental materials. Only Turker and Biskin[9], Turker and Biskin[4], Butler, et al.[9]. and Moraes, et al.[2] have evaluated the effect of carbamide peroxide agents on the surface of ceramics. In addition, there is no report in the literature regarding the influence of highly concentrated solutions on ceramics. Swift[13] and Haywood[3] reported that night-guard vital bleaching techniques have no significant effect on the color or physical properties of porcelain or other ceramic materials and amalgam or gold.

Significant changes on the ceramic surface caused by the action of bleaching agents may cause changes in the mechanical properties of the material. Therefore, the purpose of this study was to evaluate the influence of 10% and 16% carbamide peroxide bleaching agents on the surface microhardness of two ceramics. The null hypotheses to be tested are that: (1) 10% carbamide peroxide bleaching agent does not influence the microhardness VM7 ceramic surface; (2) 10% carbamide peroxide bleaching agent does not influence the microhardness VM13 ceramic surface; (3) 16% carbamide peroxide bleaching agent does not influence the microhardness VM7 ceramic surface; (4) 16% carbamide peroxide bleaching agent does not influence the microhardness VM13 ceramic surface.

MATERIALS AND METHODS

Table 1 shows the brand names, material types, main compositions, manufacturers and batch numbers of the products used in the current study.

Table 1: The brand names, material types, main components, manufacturers, and batch numbers of the products used in the current study.

Brand Name	Material Type	Main Composition*	Manufacturer	Batch number
Vita VM7	Feldspathic ceramic	SiO2: 62-65%, Al2O3: 14-15%, Na2O: 4-5%, K2O: 7-8%, CaO: 1-2%	Vita Zanhfabrik, Bad Sachingen, Germany	31570
Vita VM13	Feldspathic ceramic	SiO2: 59-63%, Al2O3: 13-16%, K2O: 9-11%, Na2O: 4-6%	Vita Zanhfabrik, Bad Sachingen, Germany	7747
Whiteness 10%	Carbamide peroxide	Carbamide peroxide, glycol, potassium ions, deionized water, carboxypolymethylene	FGM Dental Products, Joinville, Brazil	101208
Whiteness 16%	Carbamide peroxide	Carbamide peroxide, glycol, potassium ions, deionized water, carboxypolymethylene	FGM Dental Products, Joinville, Brazil	070208

* According to the manufacturer.

Forty discs measuring 4x4 mm (diameter and height) were made with the ceramic materials listed in Table 2. All the specimens were handled in accordance with the manufacturer's instructions, using a specific program for the ceramic firing (Vacumat 40 VITA, Zahnfabrik-Germany). After firing, the specimens were included in acrylic resin and finished with a polishing machine (Labpol 8-12, Extec, USA), using abrasive papers Nos. 600, 800 and 1200 (3M, St. Paul, USA) to remove any irregularities and create a flat surface. All the ceramic blocks were cleaned in an ultrasonic bath for 5 min with distilled water, and glaze fired according to the manufacturer's instructions.

The discs were divided into 4 experimental groups of 10 discs each, according to the ceramic (VM7 and VM13) and the bleaching agent concentration (10% and 16% / Whiteness, FGM Gel) (Table 3).

The samples were then taken to the hardness tester (Digital Microhardness Tester FM, Future-Tech) for Vickers hardness (VH) analysis at 50-gf loading for 15 seconds. Three indentations were performed on each sample, and the mean was calculated. Once the initial microhardness was determined, the peroxide carbamide (Whiteness – FGM 10% and 16%) was applied on the exposed surface of the ceramic materials for 8 hours, according to the manufacturer's specifications. During the time interval between the gel applications, the test specimens were stored in distilled water at 37ºC, simulating a conventional dental bleaching treatment. The process was repeated daily for 15 days. The final microhardness was measured after the last bleaching agent application, following the same process as for the initial reading. Statistical analysis was performed using Statistics 8.0 for Windows (Analytical Software Inc, Tallahassee, FL, USA). The microhardness means obtained for each specimen were analyzed by the Wilcoxon and Mann-Whitney tests ($p<0.05$) in order to determine the significant differences between initial and final microhardness of the specimens. P-values less than 0.05 were considered statistically significant in all tests.

Table 2: Experimental groups.

Groups*	Ceramic Material	Bleaching material concentration
G1	VM7[a]	10%
G2	VM7[a]	16%
G3	VM13[b]	10%
G4	VM13[b]	16%

*n = 10.
[a] Veneering ceramic with a fine structure for all-ceramic framework materials.
[b] Veneering ceramic for all metal-ceramic restorations.

RESULTS

The data obtained and the comparisons are summarized in Table 3. Wilcoxon showed that after bleaching VM7 using 10% carbamide peroxide, surface microhardness decreased significantly (G1: p=0.002); and for 16% carbamide peroxide, the microhardness exhibited no difference (G2: p=0.743). The effect of bleaching concentration differed significantly according to the Mann-Whitney test (p=0.021). Bleaching of VM13 exhibited no significant difference in the ceramic microhardness, for both carbamide peroxide concentrations, according to the Wilcoxon (G3: p=0.191; G4: p=0.511) and Mann-Whitney tests (p=0.319).

After bleaching the ceramics, VM7 showed the lowest surface microhardness value when the 10% bleaching agent was used, compared to all groups. No difference was found among the other groups after bleaching agent exposure.

Table 3: Means (± standard deviation) of HV values in experimental groups. Confidence level (95%) of the means and t-test of the matched samples*.

Groups	Period		Comparison		
	Before (mean ± standard deviation)	After (mean ± standard deviation)	CI (95%)	$t_{(df = 9)}$	p-value
G1	434 ± 57	349 ± 32	41.28 to 127.81	4.42	0.002*
G2	486 ± 22	496 ± 95	-59.66 to 80.62	0.34	0.743
G3	509 ± 29	519 ± 38	-5.88 to 25.50	1.41	0.191
G4	519 ± 24	502 ± 81	-71.03 to 38.05	0.68	0.511

*Ceramic VM 7. Wilcoxon Signed Rank Test for 10%: p = 0.011; for 16%, p = 0.759.
*Ceramic VM13. Wilcoxon Signed Rank Test for 10%: p = 0.262; for 16%, p = 0.261.
**p<0.05

DISCUSSION

The effect of the bleaching agent on dental materials is critically important, because whitening agents may cause deleterious effects, such as decrease in the microhardness[5,9,11] and increase in the roughness[4,11,15] of some restorative material surfaces. This may increase plaque accumulation or affect esthetics by changing the texture of the ceramic restoration, allowing the accumulation of pigments. The characteristics of the restorative material surface are therefore highly relevant in clinical practice[1] and ceramic restorations should be protected before any bleaching treatment[16].

In this study, the surface microhardness of the veneering porcelain was not affected by the different carbamide peroxide concentrations; however, little is known about the influence of bleaching on ceramics. The bleaching agent used in this study (16% carbamide peroxide) had no significant effect on the surface microhardness of the feldspathic porcelain, as shown in the study by Polydorou et al.[17] However, 10% carbamide peroxide decreased the microhardness of the feldspathic porcelain, which was consistent with the findings of Turker and Biskin[9].

The effect of the bleaching agent on dental material was investigated in this *in vitro* study, simulating the clinical situation as closely as possible. In other studies, home bleaching products (10-16% carbamide peroxide) were generally used for 2 or 4 weeks for 4-8 hours a day[1]; and the same was done in this study. There are few investigations on the effect of bleaching agents on ceramic restorative materials[2,4,9]. Turker and Biskin[9] evaluated the effects of bleaching agents on feldspathic ceramics and observed that 10-16% carbamide peroxide gels (applied for 8 h per day for 3 days) significantly decreased the surface hardness of the ceramic material tested, possibly due to factors such as surface topography or increased material porosity. Additionaly, the low pH of the fluoride gel may result from the hydrofluoric acid, which can lead to the etching of restorations that contain silica such as porcelain[9]. Turker and Biskin[4] report that the surface spectral analyses results indicated a decrease in the SiO_2 and K_2O_2 content of feldspathic ceramics after exposure to carbamide peroxide agents. Since SiO_2 forms the matrix, it would thus affect the surface hardness. According to the manufacturer, VM7 ceramic contains more SiO_2 content than VM13 ceramic, which contributes to explaining our results. Ceramic compositions are shown in Table 1. Thus, VM7 ceramic showed lower microhardness after exposure to 10% carbamide peroxide in this experiment, while no significant alteration was detected for VM13 ceramic for either bleaching agent concentration. In addition, the depth of the bleaching agent penetration is related to the composition of this matrix, which may explain the results of the microhardness testing.

Bleaching therapies with hydrogen peroxide releasing preparations may have a negative effect on restorations and restorative materials, as indicated in numerous *in vitro* investigations. Polydorou et al.[17] observed that clinicians do not need to replace ceramic restorations after at-home bleaching treatment when the restorations are on posterior teeth. On the other hand, Duschner et al.[18] reported that surface microhardness testing revealed no significant deleterious effects on the restoration surfaces after they were submitted to bleaching by hydrogen peroxide. Indeed, such alterations cannot be attributed to surface roughness alone, but also to substrate composition, water absorption rate due to permeability alterations, and irregularities left on bleached surfaces, which could promote changes in esthetic characteristics and accumulation of pigments[11].

In vitro studies are limited in their attempt to simulate clinical conditions. It has been shown that peroxide levels in bleaching products are depleted depending on the *in vivo* situation. In this study, the bleaching agents were not diluted or buffered with any water content, such as saliva or distilled water, during bleaching treatments, as in most other studies[9,14].

The findings of this study require rejection of the first null hypothesis that 10% carbamide peroxide bleaching agent decreases the microhardness of the VM7 ceramic surface, and confirmation of the second, third and fourth null hypotheses that 10% carbamide peroxide bleaching agent does not influence the microhardness of VM13 ceramic surface, and 16% carbamide peroxide bleaching agent does not influence the surface microhardness of VM7 and VM13 ceramics.

With the increasing use of ceramic restorations, it is important that dentists be aware of the possible effects of carbamide peroxide on these restorations. However, there are no reports in the literature indicating that bleaching may have any negative impact on restoration surfaces, which could require renewal of the restorations[1]. This study showed that there

was an effect on the surface microhardness of one material, which could result in ceramic failure if treated *in vivo*. In addition, the microhardness values observed in this study are within the clinically acceptable range, compared to the microhardness values of enamel (±350 HV), and the alterations verified would probably be clinically insignificant. After exposure to the bleaching agent, the ceramic surfaces may be vulnerable to some changes. Nevertheless, further studies are needed to elucidate these aspects more precisely.

CONCLUSIONS

Within the limitations of this study, the following conclusions were drawn:

- The microhardness of the VM7 ceramic surface was affected by 10% carbamide peroxide bleaching agent;
- 10% carbamide peroxide bleaching agent did not affect the microhardness of the VM13 ceramic surface, and 16% carbamide peroxide bleaching agent did not affect the surface microhardness of either ceramic.

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CORRESPONDENCE

Dra.Sheila Pestana Passos.
Av. Engenheiro Fracisco José Longo, 777
São Dimas. São José dos Campos
São Paulo – Brazil. CEP: 122450 000.
e-mail: sheilapestana@hotmail.com.

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