Surface Modifications on Aesthetically Restored Teeth following Home Bleaching with 16% Peroxide Carbamide

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ABSTRACT

Objectives: This clinical study evaluated the effects of a highly concentrated home-bleaching agent on the surface morphology of aesthetically restored teeth.

Methods: Specimens of human enamel and micro-hybrid composite resin were randomly adhered to the buccal side of right premolar and molar teeth of ten volunteers, who underwent a routine home-bleaching procedure with 16% carbamide peroxide on the upper jaw for 8 days. The mandibular unbleached specimens served as paired controls (n=10). Ultra-structural assessment of the sample was carried out by scanning electron microscopy, and the resulting images were blindly evaluated for topographical alterations. The differences between groups were calculated with the Mann-Whitney test adjusted at the 95% confidence interval.

Results: The bleached enamel presented significantly more morphological changes than the control group. The aspect of resin composite exposed to the whitening substance was statistically similar to that observed in the corresponding control group (P<.05).

Conclusions: The occurrence of surface topography changes during home bleaching of aesthetically restored teeth with 16% carbamide peroxide was restricted to enamel. (Eur J Dent 2011;5:157-162)

Key words: Tooth bleaching; Carbamide peroxide; Composite resin; Tooth enamel.

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INTRODUCTION

Home bleaching is a popular and convenient treatment to improve the appearance of vital teeth.[1] During this procedure, whitening gel is deposited on moulded acrylic trays that allow the solution to act indistinctly over both enamel and pre-existing aesthetic restorations. Many investigations have shown that low-concentration bleaching substances may damage these structures[1-3] and thus increase their susceptibility to staining and bacterial adhesion.[4-6]

Major colour improvements are sometimes enthusiastically desired by patients, whereas the adverse effects of whitening procedures may be unintentionally downplayed by professionals. Recently, manufacturers released a flood of high-concentration bleaching gels in the market. These gels are claimed to increase the effectiveness as well as longevity of at-home treatments. As expected, initial *in vitro* studies reported significant alterations to enamel[7,8] or composite resins.[2,9] However, these results were not confirmed by the scant evidence originating from clinical investigations.[10,11]

Since the effects of whitening substances have been evaluated separately and in a great diversity of regimens, it is difficult to extend those incompatible evidences to aesthetically restored teeth. Thus, this prospective clinical study aimed to assess simultaneously the effects of 16% carbamide peroxide on the external topography of enamel and composite resin.

MATERIALS AND METHODS
Preparation of specimens

This study was initiated only after obtaining suitable approval from the Local Ethics Committee, which is in conformity with the Declaration of Helsinki (DoH). A total of five human impacted upper third molars were included in this study. All molars included fit the following criteria: 1) arising from different donors and 2) without structural damage, signs of hypomineralisation (white spots) or prior contact with saliva. After cleaning, teeth were individually positioned in a sectioning machine equipped with a water-cooled 300-µm thick diamond saw (Minitorm, Struers A/S, Copenhagen, Denmark). Roots were removed at the cemento-enamel junction. After that, the remain-

ing crows were equidistantly sectioned in the mesiodistal and buccolingual directions to provide four enamel fragments (4 mm x 4 mm and 2 mm thickness) each.

The pieces obtained were moulded into a light regular-set silicon (Virtual Light-Body, Ivoclair Vivadent, São Paulo, SP, Brazil), and the moulds were filled with increments of a micro-hybrid composite resin (EA2 Opallis, FGM Dentscare Ltda, Joinville, SC, Brazil). Moulds were sequentially polymerised over 20 seconds using a light-emitting diode unit set between 460 and 480 mW/cm^2 (Ultra-Blue i5, DMC Vasconcellos, São Carlos, SP, Brazil) in order to produce enamel-like composite resin specimens.

The resulting 40 specimens (20 of composite resin) were then individually placed at the end of polyvinyl chloride cylinders (3/4 inch diameter and 20 mm high), which were filled with chemically-activated acrylic resin (Technovit 4000, Heraeus Kulzer, Wehrheim, Germany). After 24 hours, the exposed side of each embedded fragment was flattened and polished by sequential use of wet 400-, 600- and 1200-grit silicon carbide papers (Norton®,Guarulhos, SP, Brazil) adapted in a slow-speed polishing machine set at 150 rpm (Ballerup, Struers A/S, Copenhagen, Denmark). The finished specimens were then removed from blocks and ultrasonically cleaned for 5 minutes before being sterilised and stored in distilled water (37±0.5ºC) until use.

Ten volunteers (20-25 years old) were recruited to participate in this investigation. All volunteers presented the following inclusion criteria: absence of caries and gingivitis, no history of xerostomia, no previous bleaching therapy and willingness to understand and sign a consent form. Participants had their maxillary right teeth cleaned with a rotary toothbrush and dentifrice before isolation with a rubber dam and stainless steel clamps. The buccal sides of the right upper second premolar and first molar were etched with 37% phosphoric acid (Dentsply, Petrópolis, RJ, Brazil) for 30 seconds and immediately washed with running water for 60 seconds. To fix the enamel and composite resin randomly on these surfaces, a two-step adhesive (Adper™ Scotchbond, 3M, Sumaré, SP, Brazil) was brushed and light-polymerised for 15 seconds before an increment of low-viscosity composite resin (Natural Flow, DFL, Jacarepagua, RJ, Brazil) was

used to glue the specimens on teeth using light-polymerisation for 40 seconds.

These same procedures were performed on the adjacent lower right teeth to fix the enamel and composite resin on specimens not undergoing the bleaching process. These specimens thus served as paired controls (n=10).

Bleaching process

An upper jaw impression was taken of each participant with alginate materials (Jeltrate, Dentsply, Petrópolis, RJ, Brazil), and impressions were poured with type II dental stone (Pasom, São Paulo, SP, Brazil) to fabricate a master cast. A 0.5 mm-thick wax layer was applied on the buccal face of each cast 1.5 mm away from the gingival margin to fabricate reservoirs for the bleaching gel. Soft trays (Cristal, Bio-art, São Carlos, SP, Brazil) were made using a heat/vacuum tray-forming machine (Plasvac P7, Bio-art, São Carlos, SP, Brazil). The trays were tested and trimmed to fit the gingival margin of each volunteer.

The participants were instructed to use the tray at the upper arch and to keep the bleaching product (Whiteness Perfect 16%, FGM Dentscare Ltda, Joinville, SC, Brazil) in contact with teeth exactly 6 hours per day for 8 consecutive days. No restrictions on dietary or hygiene habits were imposed, but the necessity to remove the residual solution after each whitening session was emphasised. Every 48 hours, the volunteers were questioned about sensitivity of teeth or soft tissue. When hypersensitivity was confirmed, desensitising treatment was performed with 2% potassium nitrate (Desensibilize KF 2%, FGM Dentscare Ltda, Joinville, SC, Brazil). The four subjects were instructed to place the desensitizing gel in their tray and wear it for 20 minutes once a day, as recommended by the manufacturer.

Surface analysis

After detachment from teeth, the specimens were left to dehydrate for 96 hours before being gold sputter-coated to permit analysis in a scanning electron microscope (DSM-940 A, Carl Zeiss, Oberkochen, Germany). Digital SEM photomicrographs were taken at four different areas over the surface of each fragment at 5000x magnification. Enamel and resin surface alterations were classified qualitatively by increasing order of scores ranging from 0 (no observable alterations) to 4 (heavy erosion with deep depressions). Prior to blind analysis of the 160 images, a single examiner was calibrated by viewing 30 additional SEM micrographs. A second assessment was repeated 4 weeks after the first evaluation, and the data obtained were considered as a whole for statistical comparison.

Statistical analysis

Statistical differences between the experimental and appropriate control groups were executed with the Mann-Whitney Test adjusted to the 95% confidence interval. The intra-observer agreement was determined using Cohen's Kappa statistic. Statistical analyses were performed with SPSS software v.11.0 for Windows (SPSS Inc., Chicago, IL, USA).

RESULTS

Representative SEM images are shown in Figures 1-4, and the results of the Mann-Whitney test are presented in Table 1.

Following application of 16% carbamide peroxide, the enamel surface in the experimental group exhibited extensive mild erosion with shallow depressions and destruction of interprismatic matrix. This appearance differed significantly from that of non-bleached enamel fragments, which exhibited a smooth and amorphous aspect.

The bleached composite resin specimens displayed a flat appearance, with slight erosion and some striation due to the grinding procedure. This appearance was statistically similar to that observed in the control group (P<.05). Intra-observer agreement was 0.89.

DISCUSSION

This study was the first to adhere human enamel and resin fragments to the buccal side of regular teeth to reproduce, as closely as possible, an actual home-bleaching situation. This manoeuvre permitted controlled and continuous exposure of specimens to saliva, beverages and oral hygiene habits, a procedure completely different from prior investigations in which removable appliances were adopted to carry the specimens.[1,9-11] Therefore, such biases make previous studies difficult to interpret and compare.

Scanning electron microscopy is a simple and effective method for identifying surface morphology alterations on enamel and composite resins

submitted to home bleaching.[1,12,13] Nonetheless, dehydration and metal coating necessary to SEM analysis are able to change part of the specimens structure;[14] thus, the appearance of enamel observed may not correspond precisely to that of bleached enamel in its natural condition.

Porosity and erosion resulting from demineralisation were demonstrated by SEM after *in vitro* and *in vivo* intermittent exposure of enamel to 10% carbamide peroxide.[1,15,16] In the present study, the time of contact between the enamel and whitening gel (48 hours in total) was shorter than those adopted in other investigations[7,10,15-17] and sufficient to produce an eroded appearance similar to that of acid-etched surfaces. This finding has already been observed in vitro by Adebayo et al[8] but not *in*
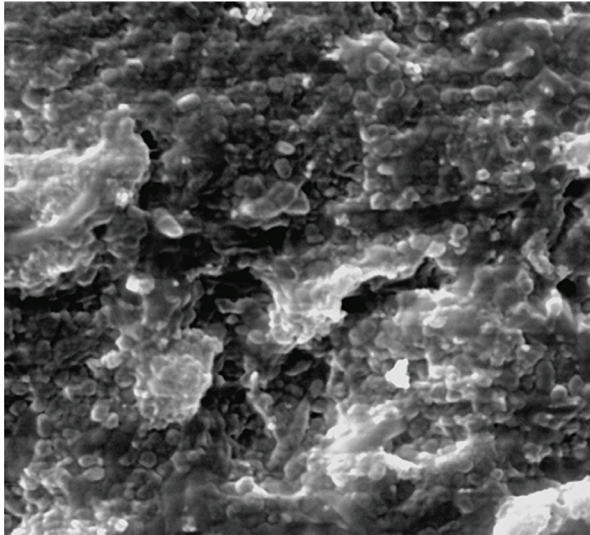

Figure 1. Representative SEM micrograph of bleached enamel at original magnification 5000x.
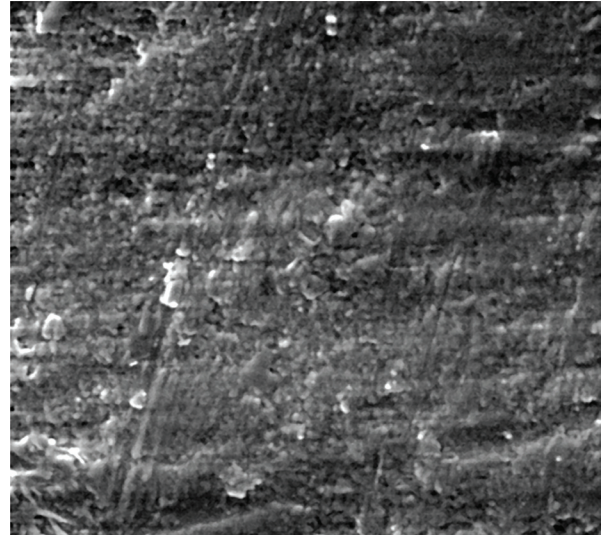

Figure 2. Representative SEM micrograph of unbleached enamel at original magnification 5000x.
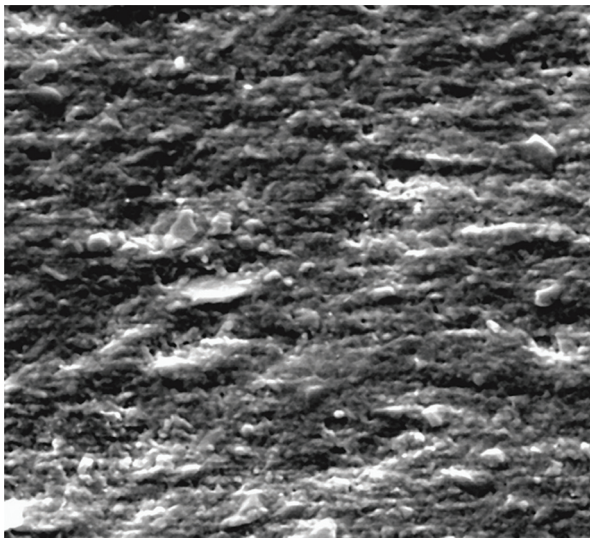

Figure 3. Representative SEM micrograph of bleached resin composite at original magnification 5000x.
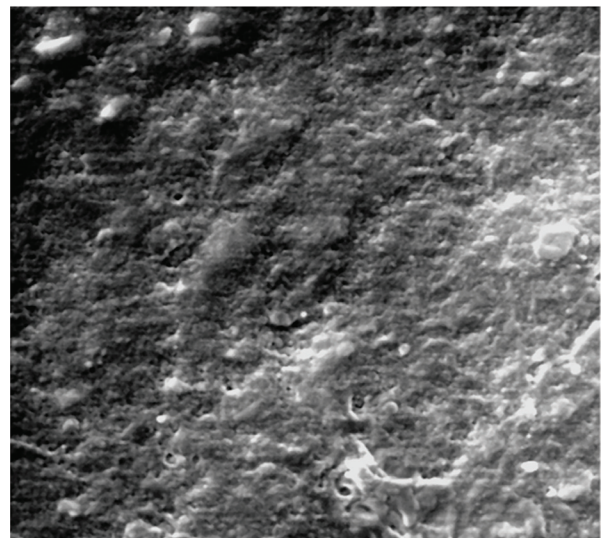

Figure 4. Representative SEM micrograph of unbleached resin composite at original magnification 5000x.

Table 1. Median values and ranges of scores attributed to enamel and resin composite micrographs (* statistically significant).

Substrate	Treatment	Median	P value
Enamel	bleached	3.4 (3.0-4.0)	0.004*
	unbleached	1.4 (1.0-2.0)	0.004*
Composite resin	bleached	2.3 (1.0-3.0)	0.091
	unbleached	1.6 (1.0-2.0)	0.091

vivo by Metz et al,[11] likely because the enamel specimens used in the latter research had prior contact with fluoride.

The damage detected on enamel could be justified by the ability of urea, derived from the reaction of carbamide peroxide with water, to denature protein structures and thus cause structural and morphological changes through the degradation of organic molecules.[14] In addition, the slightly acidic pH of the gel tested (6.04)[18] may have contributed secondarily to these external modifications.[12,17] However, a possible increased susceptibility of unerupted third molars' enamel to the action of chemical agents such as carbamide peroxide should be considered before this result can be generalized.

Since these findings were detected *in vivo*, it may be suggested that the expected dissolving and buffering effects of saliva on the whitening gel[19] or the attenuation provided for a peroxide-consuming enzyme on the surface of teeth[20] were not able to minimise the deleterious impact of a highly concentrated bleaching gel on human enamel. Alterations to enamel topography caused by low concentrations of bleaching gels may undergo repair over time by precipitation of mineral phases derived from saliva into the existing porosities.[1,16,21] Tooth remineralisation is a slow process, and the high concentration of bleaching gel used in this study probably smothered the saliva recovery properties. Clinically, however, erosion reversal should be expected as soon as whitening gel application is discontinued. In recent laboratory investigations, the addition of fluoride to carbamide peroxide gel resulted in less demineralisation and shorter periods for enamel hardening recovery following bleaching.[22,23]

The absence of significant alterations on the surface of the composite resin bleached was already described for nano-hybrid and packable resins after extended periods of *in situ* and *in vitro* exposure to 15% carbamide peroxide.[6,11] Since morphological alterations were noticed on enamel specimens subjected to the same home-whitening conditions, we inferred that salivary attenuation of the highly concentrated peroxide carbamide substance did not completely respond for resin resistance to bleaching detrimental effects.[19,20] Enamel and composite are completely different materials, and an incompatibility between the solvents present in the whitening substances and the components in the polymer matrix of the resin-based material may

justify the absence of deleterious effects on resin surfaces. [2,11,13,24]

Another possible explanation for the absence of statistical difference between groups relates to the subjective and qualitative evaluations necessary for the SEM micrographs and also to the low number of composite resin specimens used; it is possible that major changes in the surface of bleached resin have been underrated, despite the effort to calibrate the examiners, thus reducing the numerical difference between groups. Although not widespread as SEM, atomic force microscopy (AFM) enables quantitative and independent measurement of specimens' surface morphology in their natural condition.[17] Thus, the possibility of getting different results, if AFM had been used, cannot be disregarded.

Colour improvements have been described separately for enamel[25] and composite resin.[26] Since these structures were bleached together in this investigation, we provide evidence that these substrates responded differently to 16% carbamide peroxide. This phenomenon may justify the common observation of poor colour matching of pre-existing restorations after home whitening.[11] Nonetheless, given the diversity of composite resins available, the susceptibility of their surfaces to this or other vital bleaching regimens and formulations may be different.

To date, it is uncertain how the surface changes that occur during bleaching are related to colour improvement and/or increases in staining susceptibility.[5,6] However, the complete repolishing of aesthetically restored teeth to recover smoothness and delay staining of composite resins[9,27] may both be unnecessary, at least for the material studied, and thus avoid the irreversible loss of enamel structure.

CONCLUSIONS

Within the limitations of this clinical study, we concluded that the occurrence of surface topography changes during home bleaching of aesthetically restored teeth with 16% carbamide peroxide was restricted to enamel.

ACKNOWLEDGMENTS

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