Effect of different bleaching protocols on surface roughness of human dental enamel and nanofilled resin composite

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Abstract: Background: Bleaching considered a conservative techniques for treatment of discolored human teeth. Although bleaching is safe to soft tissues from a procedural standpoint, but it may not be safe for dental tissues and materials. The effects of such oxidizing agents on enamel and esthetic restorative material surface roughness, however not been widely studied. Surface roughness of enamel and restorations is one clinical important physical property that warrants investigation**. The Aim** of the study is to evaluate of the effect different bleaching agents on surface topography of Enamel surface and nanofilled resin composite. **Objectives:** In this study 30 % carbamide peroxide, 40% hydrogen peroxide and 10% carbamide peroxide bleaching agents were performed on 40 extracted teeth and 40 disc of nanofilled resin composite to evaluate their effects on surfaces roughness of enamel and nanofilled resin composites. **Method:** The buccal surfaces of forty extracted anterior teeth were flattened as parallel as possible without exposing dentin. Forty Disc shape nanofilled resin composite samples were prepared. The samples were randomly divided into 4 groups: *Group A* teeth and composite discs were bleached with CP at 30% of 1 application for 30 minutes /application; *Group B* teeth and composite discs were bleached with HP at 40% for 20 minutes /application and *Group C* teeth and composite discs were bleached with CP at 10% for 8 hours._*Group D*: The control group, samples were kept in artificial saliva. Statistical analysis of Data were presented as mean and standard deviation (SD) values. Two-way Analysis of Variance (ANOVA) was used in testing significance for the effect of bleaching, substrate and their interactions on mean Ra. **Results:** There was no statistically significant difference between mean Ra of the 30% Carbamide peroxide, 40% Hydrogen peroxide and 10% carbamide peroxide bleaching techniques; all showed the statistically significantly highest mean Ra values. Control group showed the statistically significantly lowest mean Ra value. **Conclusion:** According to the results of this study various bleaching agents promote superficial changes in enamel structure surface and affect topography of nanofilled resin composite.

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Key words: Vital bleaching, carbamide peroxide, hydrogen peroxide, surface roughness, enamel and nanofilled composite

1. Introduction

Bleaching of discolored enamel is technically an easier treatment and more acceptable in comparison to other restorative techniques that result in irreversible loss of enamel and alteration of tooth contour [1]. There are different methods and materials for bleaching the teeth: in-office bleaching with hydrogen peroxide, Nightguard vital bleaching with carbamide peroxide, and microabrasion of enamel with hydrochloric acid. Bleaching with 30% to 35% hydrogen peroxide may be performed in the office using heat or light to promote the reaction [2,3].

Carbamide peroxide in concentrations ranging from 10% to 22% is the most common agent used for the at-home treatment, whereas for in office bleaching, usually hydrogen peroxide ranging in concentration from 35% to 50% is used. High concentrations of carbamide peroxide in office and low concentrations of hydrogen peroxide at home are also used.[4,5]. These bleaching solutions have been reported to cause a wide variety of changes in enamel and dentin. Although carbamide peroxide has been related to demineralization of enamel (up to 50 µm in depth), [(6)] in lower concentrations of 10% or 16%, it actually reduces the susceptibility to dental caries [(5)]. Following application of some commercial forms, a loss in mineral content of the dentin has been reported.[(7)] Also, it has been reported that if the bleaching material is applied with a toothbrush, the enamel roughness will be increased [(8)].

The change in tooth color is the result of a complex physical and chemical interaction between the tooth and the pigmentation factor [(9)]. Bleaching treatment for vital teeth is a conservative technique obtaining suitable results when compared to more invasive procedures used in aesthetic and cosmetic rehabilitation [(10)].

Some patients asking bleaching treatment may have some of their teeth restored with different kinds of aesthetic restorations, the most common among which are resin composites. The response of these existing restorations to bleaching affects the overall aesthetic result of the bleaching process. Also, any alterations in the surface topography or staining susceptibility of the resin composite due to bleaching may compromise the future aesthetic performance of the restoration [11].

In this context, the aims of this study were to evaluate the effect of different bleaching systems on surface roughness of enamel and nanofilled resin composite. The hypothesis tested is that the use of 30 % carbamide peroxide , 40 % hydrogen peroxide and 10 % carbamide peroxide , bleaching agents increases enamel and nanofilled resin composite roughness by changing its topography.

2. Materials and methods:

Enamel Specimens – Bleaching Procedures:

Forty freshly extracted human anterior teeth were cleaned and stored in saline until use. Using a double-face diamond disc (KG Sorensen,So Barueri, SP, Brazil) in a low-speed handpiece (Kavo, Biberach, Germany) under copious water spray, the root portion were cut and eliminated. The buccal surfaces were then flattened as parallel as possible without exposing dentin with 600, 1200 and 1500 grit SiC paper (Norton, Paulo, SP, Brazil). The specimens were viewed under a stereomicroscope with 10 magnification to verify the absence of exposed dentin.. An elastomeric matrix was used to control thickness and flow of the bleaching agent. The samples were embedded into cylindrical polystyrene molds (Cristal, Piracicaba, SP, Brazil) and polished with 6, 3, ½ and ¼ µm diamond grit (Arotec, So Paulo, SP, Brazil).

Composite specimens:

Disc shape composite samples were prepared using a circular Teflon mold 5mm in diameter and 2mm thickness. The mold is adapted on cellouide strip on glass slap, filled with nanofilled composite (Filtek Z350 XT). Then covered with other cellouide strip on glass slap. The samples were then photopolymerized using a halogen light source (Visulux curing unit, Vivadent; Schaan, Liechtenstein). The output of the light curing unit was regularly checked (500 mW/mm2). The samples were then retrieved from the mold and their lower surfaces were also photopolymerized for 40 seconds. The cured samples were then stored in distilled water at 37oC for 24 hours, before any testing, to ensure complete polymerization.

The samples were randomly divided into 4 groups (n = 10),each group of 10 teeth samples and 10 nanofilled resin composite discs, :

Group A : CP at 30% (VivaStyle 30%, Ivoclar Vivadent, USA) of 1 application for 30 minutes /application; **Group B:** HP at 40% (40% HP – Power Whitening system PF,Ultradent,USA) for 20 minutes /application and **Group C:** CP at 10% (10% CP – Opalescence PF, Ultradent,USA) for 8 hours, which were treated following the manufacturers' instructions (Table 1). **Group D:** The control group was not bleached and was kept in artificial saliva. An approximately 1-mm-thick bleaching gel layer was applied on enamel surface. The thickness was controlled using an elastomeric matrix. In order to simulate a nightguard situation, CP10% samples were kept in plastic containers with small amount of artificial saliva, over the time of gel application. After the last session of each group, the samples were rinsed with deionized water and stored in artificial saliva at 37°C.

Surface Roughness Test :

The optical methods tend to fulfill the need for quantitative characterization of surface topography without contact [12]. Specimens were photographed using USB Digital microscope with a built-in camera *(Scope Capture Digital Microscope, Guangdong, China)* connected with an IBM compatible personal computer using a fixed magnification of 50X.The images were recorded with a resolution of 1280 × 1024 pixels per image. Digital microscope images were cropped to 350 x 400 pixels using Microsoft office picture manager to specify/standardize area of roughness measurement. The cropped images were analyzed using WSxM software (5 develop 4.1, Nanotec, Electronica, SL) [13]. Within the WSxM software, all limits, sizes, frames and measured parameters are expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the software. Subsequently, a 3D image of the surface profile of the specimens was created. Three 3D images were collected for each specimen, both in the central area and in the sides at area of 10 µm × 10 µm.WSxM software was used to calculate average of surface roughness (R_a) of the average height of every specimen, expressed in µm, which can be assumed as a reliable indices of surface roughness[14].

Statistical Analysis

Data were presented as mean and standard deviation (SD) values. Regression model using two-way Analysis of Variance (ANOVA) was used in testing significance for the effect of bleaching, substrate and their interactions on mean Ra.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20.

Table (1) Composition and manufacture of the tested materials.

Material	Composition	Manufacture
Carbamide peroxide	VivaStyle 30%, Ivoclar	Vivadent, USA
Hydrogen peroxide	40%Power Whitening system PF	Ultradent,USA
Carbamide peroxide	10% CP – Opalescence PF	Ultradent,USA
Filtek Z350 XT	(20 nm silica filler 4-11 nm zirconia filler) as 72.5% by w filler bis-GMA, UDMA,TEGDMA, PEGDMA and bis-EMA resins	3M ESPE

3. Results

Two-way ANOVA results

The results showed that bleaching, substrate and the interaction between the two variables had a statistically significant effect on mean Ra.

Effect of Bleaching

The mean and standard deviation values of Ra were 0.251 ± 0.001, 0.250 ± 0.002, 0.250 ± 0.001 and 0.246 ± 0.006 for 30% Carbamide peroxide, 40% Hydrogen peroxide, 10% carbamide peroxide and control groups, respectively.

There was no statistically significant difference between mean Ra of the 30% Carbamide peroxide, 40% Hydrogen peroxide and 10% carbamide peroxide bleaching techniques; all showed the statistically significantly highest mean Ra values. Control group showed the statistically significantly lowest mean Ra value (tables 2,3).

Table (2): Regression model results for the effect of different variables on mean Ra

Source of variation	Type III Sum of Squares	df	Mean Square	*F*-value	*P-value*
Bleaching	0.0008	3	0.0002	18.4	<0.001*
Substrate	0.0009	1	0.0009	61.3	<0.001*
Bleaching x Substrate	0.0008	3	0.0003	18.9	<0.001*

df: degrees of freedom = (n-1), *: Significant at P ≤ 0.05

Table (3): Comparison between Ra of bleaching techniques regardless of substrate

30% Carbamide peroxide		40% Hydrogen peroxide		10% Carbamide peroxide		Control		*P*-value
Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	
0.251 [a]	0.001	0.250 [a]	0.002	0.250 [a]	0.001	0.246 [b]	0.006	<0.001*

*: Significant at P ≤ 0.05

Effect of substrate

The mean and standard deviation values of Ra were 0.248 ± 0.003 and 0.251 ± 0.001 for teeth and composite, respectively.

Composite showed statistically significantly higher mean Ra than teeth.

Table (4): Comparison between Ra of the two substrates regardless of bleaching

Teeth		Composite		*P*-value
Mean	±SD	Mean	±SD	
0.248	0.003	0.251	0.001	<0.001*

*: Significant at P ≤ 0.05

Effect of different interactions

There was no statistically significant difference between (Teeth bleached with 30% Carbamide peroxide), (Composite bleached with 30% Carbamide peroxide), (Composite bleached with 40% Hydrogen peroxide), (Composite bleached with 10% carbamide peroxide) and (Unbleached Composite); all showed the statistically significantly highest mean Ra values.There was no statistically significant difference between (Teeth bleached with 40% Hydrogen peroxide) and (Teeth bleached with 10% carbamide peroxide); both showed statistically significantly lower mean Ra values.Untreated teeth showed the statistically significantly lowest mean Ra value.

From the interactions table, we can also conclude the following:

- As regards teeth; 30% Carbamide peroxide showed the statistically significantly highest mean Ra. There was no statistically significant difference between 40% Hydrogen peroxide and 10% carbamide peroxide; both showed significantly lower mean Ra. Unbleached teeth showed the statistically significantly lowest mean Ra.
- As regards composite; there was no statistically significant difference between the three bleaching techniques and control group.

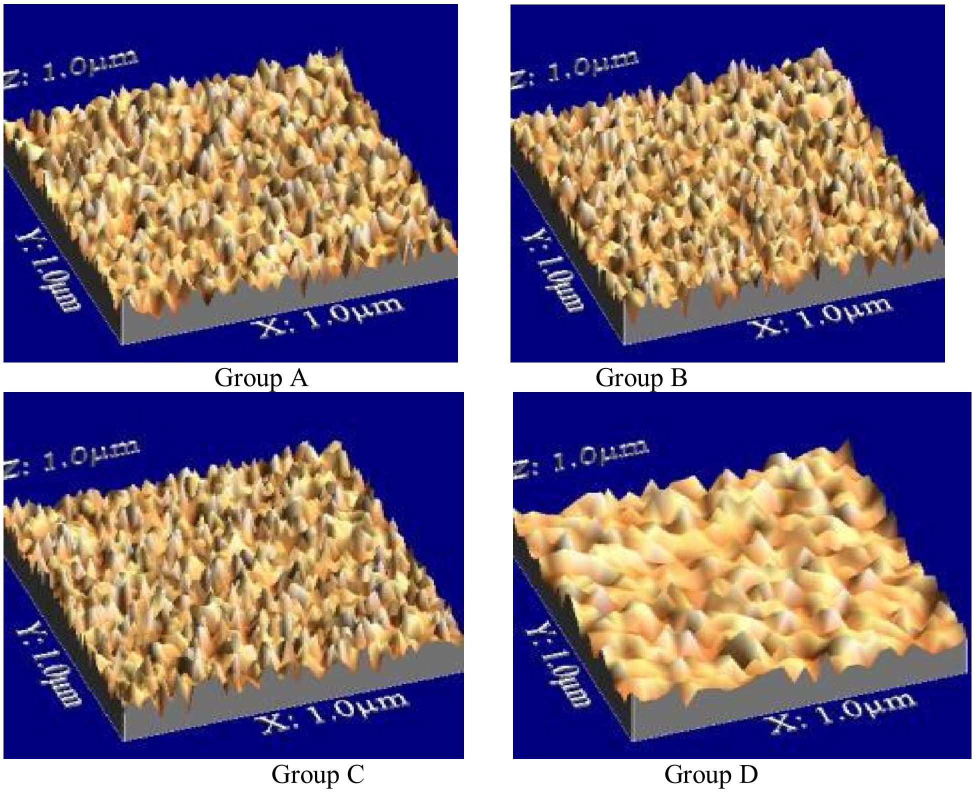

Figure (4): Microscopic images showing the surface topography of representative Enamel samples for the four teeth groups

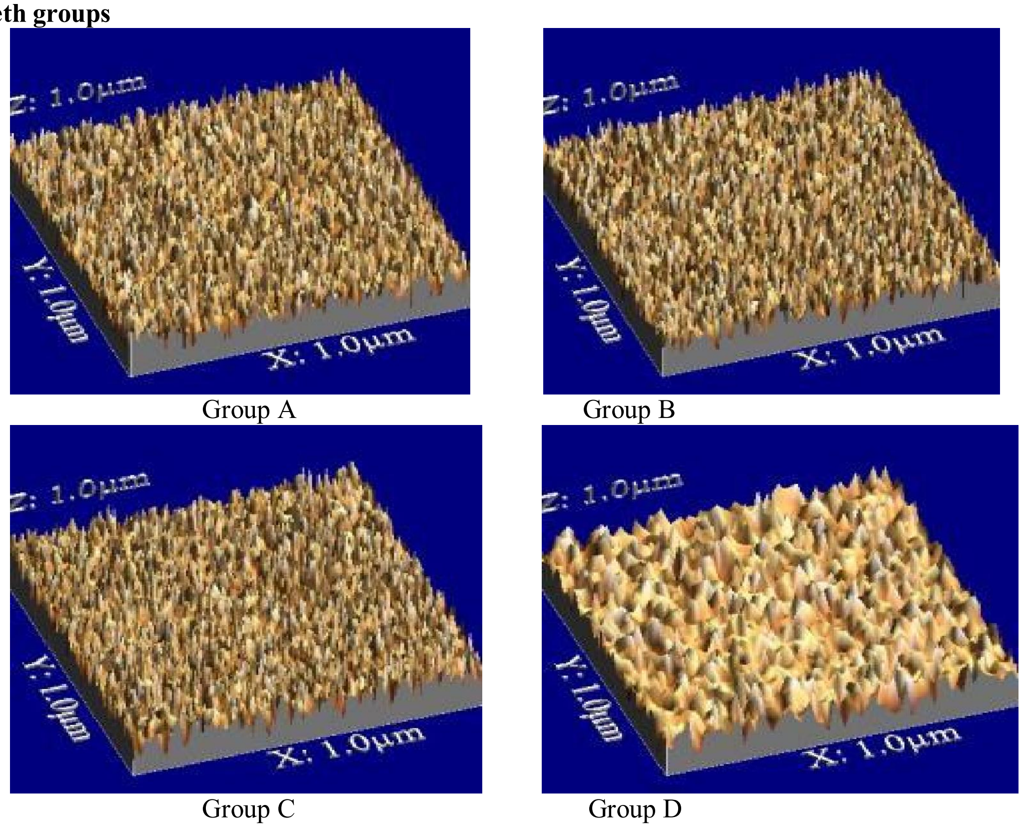

Figure (5): Microscopic images showing the surface topography of representative tested nanofilled resin composite samples for the four composite groups.

Table (5): Comparison between Ra of different variables' interactions

Bleaching	Substrate	Mean	SD	*P*-value
30% Carbamide peroxide	Teeth	0.251 [a]	0.001	<0.001*
	Composite	0.252 [a]	0.001	
40% Hydrogen peroxide	Teeth	0.249 [b]	0.001	
	Composite	0.252 [a]	0.001	
10% carbamide peroxide	Teeth	0.249 [b]	0.001	
	Composite	0.251 [a]	0.001	
Control	Teeth	0.242 [c]	0.001	
	Composite	0.252 [a]	0.002	

*: Significant at $P \leq 0.05$, Different letters are statistically significantly different

4. Discussion:

Bleaching treatment for vital teeth is a conservative technique obtaining suitable results when compared to more invasive procedures used in aesthetic and cosmetic rehabilitation [10]. Since many patients demanding dental bleaching already have one or some of their teeth restored by resin composite, studying the effect of bleaching on the surface roughness and topographical changes of Enamel surfaces and nanofilled resin composite became essential. Nanofilled resin composite is selected in the current study since its wide use in dental clinics due to highly smooth surface with good esthetic appearance.

In this study, the tested hypothesis was confirmed. The enamel surfaces exposed to bleaching agents presented many high peaks and many deep troughs.

There was no statistically significant difference between mean Ra of the 30% Carbamide peroxide, 40% Hydrogen peroxide and 10% carbamide peroxide bleaching techniques; all showed the statistically significantly highest mean Ra values. These findings in acceptance with other studies reported that whitening products containing hydrogen peroxide at concentrations of 5.3–38%, or 10–37% carbamide peroxide induced surface alterations. [15-19] These may be explained by the oxidative process and the pH of bleaching agent are regarded as the main causes of the adverse effect of dental enamel after the bleaching treatment. The capacity of the oxidative process to create irregularities on the surface of bleached enamel is questionable as the peroxide activation nature and the interaction with the various bleaching gel components need to be determined [20]. According Price et al. [21],it is unclear whether the pH of products containing CP or HP undergoes similar changes in the oral cavity or whether these changes can affect the dental tissues during the bleaching process and the intraoral temperature can affect the pH.

In this study bleached nanofilled composite showed statistically significantly higher mean Ra than enamel surfaces. Also as regards composite; there was no statistically significant difference between the three bleaching techniques and control group.

These findings may be explained by manufacturing method of nanofilled resin composites show a bimodal filler distribution consisting of non-agglomerated nanosilica particles as well as nanocluster formed of loosely bound agglomerates of primary zirconia/silica particles (3M, Filtek Z350 Universal Restorative technical profile, 2005).These agglomerated clusters are highly porous. During manufacturing, these nanoclusters are subjected to a "dual silanization" process before being added to the resin matrix. First,the clusters are infiltrated with a "dilute" silane coupling agent to help infiltration of the silane into the cluster interstices then, a second "undiluted"silane coupling agent is admixed with the 'nanoclusters' prior to incorporation into the resin matrix. However, it has been reported that even the infiltrated nanoclusters still possess some internal interstitial porosity. This porosity may provide narrow pathways for the peroxide and for the produced radicals to diffuse through. Thus, the peroxide will not only attack the coupling agent at the surface, but it will be able to reach and degrade the coupling agent at even deeper levels leading to more filler debonding and subsequently more roughness. It also seems logic that the "dilute" coupling agent that infiltrates the clusters is more easily degraded chemically by the peroxide.This may cause rapid deterioration of the coupling agent inside the clusters leading to more dislodgement of the primary particles forming the clusters and consequently more roughness [22].

5.Conclusions:

Various bleaching agents promote superficial changes in enamel structure surface and affect topography of nanofilled resin composite

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