Effect of Over-the-Counter Whitening Products on Enamel Color Change and Surface Roughness - A laboratory Study

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Abstract:

Objective: To evaluate the effect of various over-the-counter whitening products on enamel color change and surface roughness. **Materials and Methods:** Ninety bovine teeth were collected and sectioned at the cementoenamel junction. Fifty teeth were selected and stained for color change test. They were randomly divided into five groups according to the whitening product applied (n= 10). Color measurements were carried out with a spectrophotometer. The remaining Forty teeth were used for surface roughness test, where they were randomly divided into four groups n=10. Surface roughness was evaluated with optical profilometer. **Results:** The color change (ΔE) was significantly greater in the group that was treated with whitening strips (p=0.05) only. No statistical difference was found when other tested groups were compared with each other. The surface roughness was significantly higher in all groups in comparison to the initial one. No significant differences were found among over-the-counter (OTC) products with respect to surface roughness (P=0.248). **Conclusions:** All OTC whitening products didn't give the predicted effect on color change except with whitening strips. Meanwhile, they had a great effect on enamel surface roughness.

Introduction:

The quest for novel ways to merge dental and practical aspects has driven the evolution and refinement of dental esthetics. As a result, the demand for tooth whitening has increased significantly, and a wide range of products, techniques, and procedures have been offered to the dentistry market.[1] Extrinsic and intrinsic reasons can discolor vital and non-vital teeth, reducing the appearance of a smile.[2]

Because they can be used on a daily basis, consumers are able to misuse these products by wide range of over-the-counter (OTC) products on the stores. Higher frequency of use and shorter bleaching treatments lower the amount of time the teeth are exposed to saliva, which can decrease remineralization. This reduction in remineralization increases the potential for tooth enamel damage significantly[3] and subsequent bleaching agents induce structural variations on enamel surface.[1,4] The availability and easy access to OTC bleaching products have increased their popularity. This regime is less time consuming, low cost, and avoids the need for an extra appointment with the dentist as compared with professionally prescribed home bleaching agent.[5]

Assumed to the widespread market availability of OTC products and the deficiency of use impact assessments, this study was designed to assess the whitening outcome of OTC products and their effect on enamel surface roughness.

Null Hypothesis

This study was designed to test the null hypotheses that neither color nor surface roughness of enamel would be affected by over-the-counter whitening products.

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Materials and Methods:

Materials:

Four OTC whitening products were selected for the current study.

Crest 3D White strips-advanced vivid (Procter & Gamble, Cincinnati, OH, USA), Colgate Optic White (Colgate-Palmolive, CP, Egypt), Dazzling white paint on gel pen (Grosvenor Consumer Products, Ontario, Canada) and Crest 3D White Multi-Care whitening mouthwash (CR) (Procter & Gamble, Cincinnati, OH, USA).

Methods:

Freshly extracted bovine incisors were collected, cleaned, stored and disinfected in 1% thymol solution at 37℃ for 24 hours then examined by binocular Stereomicroscope (30X magnification, SZ TP, Olympus, Tokyo, Japan) to exclude the cracked, fractured and defective ones. Finally, 90 Incisors were chosen and stored in distilled water at 4°C until they were used within one week of being collected. All the roots were sectioned 2mm apical to the cementoenamel junction. The remaining pulp tissue in each tooth was removed using sharp excavator. Teeth were inserted in transparent (tooth shade) self-cure acrylic resin blocks. The teeth were then stored in distilled water at 4℃ until use to avoid dehydration.

Teeth Grouping

The teeth were randomly divided into five groups n= 10 according to the whitening material was applied for color change test and into four groups for surface roughness test (the same groups of color test with no control group).

Color Change Test

Fifty teeth were selected and stained by immersion in tea solution to make the teeth color more detectable.

Protocol of staining

An immersing solution was made by boiling 1.8 g of black tea ((Lipton, Unilever, Egypt) with 100 mL of

distilled water for 3 minutes, and infusing for 5 minutes for six days, the tea solution was changed every 24 hours. For color stabilization teeth were preserved in artificial saliva solution prepared by (Nile Research Center, Mansoura, Egypt), for one week at 4°C which was changed daily.

Group 1: Control group, the specimens were immersed in distilled water and incubated (BTC incubator, 20L, Egypt) at 37℃, the solution was changed daily.

Group 2: The specimens was bleached using bleach strip (Crest 3D White strip), a piece of strip was sticked on enamel surface for 30 minutes daily in a humid atmosphere (covered by wet tissue) at 37°C. This procedure was repeated for 14 days.

Group 3: A whitening toothpaste (Optic white Colgate toothpaste) was used to brush the specimens by an electric toothbrush with a soft bristle (Oral B Triumph; Braun, Kronberg, Germany). Each specimen was placed in a plastic container and brushed with the prepared toothpaste mixture for 2 minutes twice daily for a total of 12 weeks.

Group 4: Each specimen was painted with a paintbrush was to apply the gel (Dazzling white paint on gel) for 10 minutes/twice daily. The procedure repeated for 28 days.

Group 5: The specimens were immersed in (Crest 3D white mouthwash) for 1 min/twice daily for 56 days.

Color Measurement

The colors of the specimens were measured three times: before staining, after staining, and after application of the whitening materials, using a portable reflective spectrophotometer (X-Rite, model RM200QC, Neu-Isenberg, Germany). The following formula was used to evaluate the color changes (E) of the specimens:

ΔECIELAB = (ΔL^2 + Δa^2 + Δb^2) ½

Where: L* = lightness (0-100), a* = (alteration the color of the axis red/green) and b* = (color variation axis yellow/blue).

Surface Roughness Test

Forty teeth were selected for surface roughness test. To standardize the surface roughness of the enamel, the facial enamel surface was flattened with rotary diamond finishing disc mounted to straight angle handpiece (NSK, Ultimate500, United States). For the final polishing, silicon carbide paper (Siawat, 1913, Switzerland) with different grades (P800, P1000, P1200) were used respectively each for 30 seconds.

Surface Roughness Measurement

Two readings of surface roughness were taken; initially (after enamel surface preparation) and final reading after application of whitening material. Surface roughness was measured using a non-contact optical profilometer, specimens were photographed using a USB Digital microscope with a built-in camera (U500X, Digital Microscope, Guangdong, China) connected to an IBM compatible personal computer at a fixed magnification of 120X, the collected images were investigated using WSxM software.

Statistical analysis

The Statistical Package of Social Science (SPSS) program for Windows was used to analyze the data (Standard version 26). Shapiro-Wilk test was used for test of normality. Continuous variables were given as mean and standard deviation for parametric data. The before and after groups were compared using the paired t-test. When comparing more than two groups, the ANOVA test was applied, and when comparing groups in between, the post-hoc LSD test was used. Continuous variables were correlated using Pearson correlation (parametric).

Results:

Color Change Test:

The color difference of teeth after staining and after bleaching (ΔE) was statistically significant between the tested groups, according to one-way ANOVA. Tukey HSD post-hoc test revealed that ΔE of the Whitening strips group was significantly higher than other tested groups, p1= 0.007, except with mouthwash p4=0.462, (Table 1).

Surface Roughness Test

Paired t-test revealed that there was significant increase in surface roughness of enamel after bleaching when compared to that before bleaching in all tested groups P≤0.001. Regarding to surface roughness after bleaching, there was no significant difference among studied groups when compared to each other P=0.248, (Table 2).

Correlation between Color and Surface Roughness

Pearson's correlation between color difference (ΔE) and surface roughness after bleaching among the four tested groups showed that there was statistically negative correlation, (Table 3).

Table 1: Mean and SD of color difference (ΔE) between studied groups

Groups	Color difference (E) Mean ± SD	ANOVA P value	Post-hoc LSD test			
			P1	P2	P3	P4
Group 1	13.74±5.75	F=2.58 P=0.05*	-	-	-	-
Group 2	22.99±7.65		0.007*	-	-	-
Group 3	14.48±6.94		0.825	0.013*	-	-
Group 4	15.48±8.75		0.600	0.028*	0.761	-
Group 5	17.93±7.43		0.210	0.132	0.300	0.462

Table 2: Mean and SD of surface roughness between the studied groups

Groups	Surface roughness				Paired t -test	P value
	Before		After			
	Mean ± SD	Min-Max	Mean ± SD	Min-Max		
Group 1	0.252±0.002	0.25-0.26	0.261±0.002	0.26-0.27	6.52	≤0.001*
Group 2	0.253±0.003	0.25-0.26	0.264±0.003	0.26-0.27	6.20	≤0.001*
Group 3	0.251±0.008	0.23-0.26	0.262±0.002	0.26-0.27	4.87	0.001*
Group 4	0.252±0.003	0.25-0.26	0.261±0.004	0.26-0.27	5.36	≤0.001*

Table 3: Correlation between surface roughness and color difference (ΔE)

Color difference (E)	Surface roughness	
	r	p
White strips (n=10)	-0.291	0.415
Toothpaste (n=10)	-0.282	0.431
Paint on Gel (n=10)	-0.693	0.026*
Mouthwash (n=10)	-0.228	0.526

Discussion:

The present study evaluated four over-the-counter bleaching products, freely accessible to the general population. The products were applied to bovine enamel surfaces, for different periods of time, aiming to identify potential color change and surface roughness of enamel. Hydrogen Peroxide (HP) was the active agent in all tested materials with difference in concentrations and mode of application.

It's possible that bovine teeth, rather than human teeth, restricted the study's findings. Bovine teeth, on the other hand, may effectively replace human teeth in terms of enamel and dentin qualities.[6] Bovine tooth hard tissues are frequently utilized as substitutes for human teeth in studies because their chemical composition and structure are comparable to those of human teeth [7]. An earlier study found that whitening effects on bovine and human teeth were identical.[8] In protocol studies similar to this one, bovine teeth are easier to obtain, despite having less mineralization,[9] and are observed as suitable alternatives for human teeth.[10] The specimens were kept in distilled water for the duration of the application because storing them in artificial saliva could have resulted in the formation of a protective salivary film,[11] which may have affected the surface roughness values and possible remineralization effect.[12]

By observing the specimens' mean values of ΔE (color difference of specimens after staining and after bleaching), it was found that the whitestrips group showed the highest statistically color variation and differed significantly from the other groups except when compared to mouthwash group. This result may be explained by increased concentration of HP result in more whitening effect as the white strips were the highest in HP concentration (9.5%) than other tested materials. Previous study has shown that strips are effective and similar to the trays with carbamide peroxide[13].

The profilometer interpretations showed a significant increase in the roughness of the enamel surface in all experimental groups in this study when compared to the initial roughness of each single group. However, no significant difference was found when comparing tested groups with each other.

Roughness value was the highest in toothpaste group, this may be due to high abrasive amounts that can damage the dental hard and soft tissues. Pyrophosphate is the whitening chemical in commercial whitening dentifrices, but Colgate Optic White also contains hydrogen peroxide. Some studies claim that dentifrices containing both silica and pyrophosphate cause more enamel wear than silica-only dentifrices.[14,15]

Increased surface enamel roughness can occur as a result of the bleaching solutions' low pH. As a result of the low pH bleaching solution, demineralization alterations with erosion patterns are expected to occur irreversibly as a factor in the bleaching reactions.[16] The pH of OTC bleaching products is lower than that of professionally recommended bleaching procedures, causing erosive effects on the enamel surface.[17,18] such outcomes validate studies by Lima et al.[19] and Fernandes et al.[20] who noted that prolonged acid contact to the teeth can lead to several problems.

A negative correlation was found between the enamel roughness alteration values and the ΔE values of the color difference. Several processes may occur when the light interacts with the object, including reflection, transmission, absorption, dispersal, and fluorescence that may be affected by object's surface features.[21] A previous study[22] found that the relation between the physical surface properties of bleached enamel, represented by alteration of micro hardness or of roughness and the color properties was compared with the multivariate analysis of the canonical correlation that shows that 21 % variation in the physical surface variable is explained by variation in tooth color.

Conclusions:

Within the limitations and according to the results of the current study, the following conclusions can be drawn:

•Whitening Strips showed a noticeable tooth color change.

•Whitening toothpaste, paint on gel and whitening mouthwash didn't give the desirable whitening effect.

•All OTC whitening products used, caused a high increase in enamel surface roughness.

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