ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 7, Issue – 2, March – 2024, Page No. : 160 - 167

Effect of non-carbamide peroxide over-the-counter bleaching products on tooth-whitening and microhardness on enamel surface: an in vitro study.

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Citation of this Article: Dr. Anita Kale, Dr. Ramchandra Kabir, Dr. Yamini D Khotele, Dr. Amol Badgire, Dr. Abhishek Badade, Dr. Ajit Shinde, "Effect of non-carbamide peroxide over-the-counter bleaching products on tooth-whitening and microhardness on enamel surface: an in vitro study", IJDSIR- March – 2024, Volume –7, Issue - 2, P. No. 160 – 167.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Objectives: Aim of this in-vitro study was to evaluate the effect of non-carbamide peroxide over-the-counter bleaching products on tooth-whitening and microhardness on enamel surface.

Materials and Methods: 52 human molars were randomly subjected to aqueous staining media consisting of coffee at 50^0 C for 4 days. L*a*b* colour parameters were recorded at baseline(T_0) by spectrophotometry and microhardness of stained enamel surface was recorded at baseline(T_0) by Vickers microhardness test. Permanent molars were grouped into 4 groups depending on OTC whitening agents used as per manufacturer`s instructions: Group A (Sodium hexametaphosphate containing toothpaste), Group B (Phthalimido-peroxy-caproic acid containing toothpaste), Group C (Sodium

tripolyphosphate containing toothpaste) and Group D (Blue Covarine containing toothpaste). L*a*b* colour parameters of respective OTC were recorded at one day(T_1) and one month(T_2) post-treatment by spectrophotometry. Also, microhardness of teeth by Vickers microhardness test at one day(T_1) and one month(T_2) post-treatment was recorded.

Statistical analysis: Data were analyzed using One-way ANOVA Test & Post-hoc Tukey`s Test.

Results: There was significant difference in the groups containing sodium hexametaphosphate, phthalimido-peroxy-caproic acid, sodium tripolyphosphate & blue covarine; where sodium hexametaphosphate containing toothpaste showed significantly highest whitening effect followed by phthalimido-peroxy-caproic acid, blue covarine& sodium tripolyphosphate and there was reduction in enamel surface microhardness in sodium hexametaphosphate followed by phthalimido-peroxy-caproic acid, sodium tripolyphosphate & blue covarine.

Conclusion: Among the experimental group, sodium hexametaphosphate containing toothpaste showed significant whitening effect than other over-the-counter whitening products. Also, there was reduction in enamel surface microhardness with toothpaste containing sodium hexametaphosphate followed by phthalimido-peroxy-caproic acid, sodium tripolyphosphate & blue covarine.

Keywords: Blue Covarine, Color Stability,Phthalimido-Peroxy-Caproic Acid, Sodium Hexametaphosphate, Surface Microhardness.

Introduction

Tooth whitening is a popular and desired treatment to improve upon the smile aesthetics and overall quality of life[1].Current tooth bleaching materials to be used in office as well as home, exclusively use peroxide compounds such as carbamide peroxide and hydrogen peroxide (H_2O_2)[2]. Over the counter bleaching products (OTC) are also available as a low-cost alternative, to be used, without dentist supervision[3].

The concentration of peroxides in over-the-counter (OTC) products has been restricted to levels much lower than those recommended for vital tooth bleaching to avoid the harmful effects of high peroxide concentration particularly hypersensitivity and dentin erosion[4]. Hence this maybe a reason why recently introduced OTC products containing 'non-hydrogen peroxide' agents such as Sodium hexametaphosphate, phthalimido-peroxy-caproic acid, sodium tripolyphosphate and blue-covarine are gaining more attention.

Sodium hexametaphosphate inhibits stain chromogen adsorption reducing overall extrinsic staining. Phthalimido-peroxy-caproic acid has a high potential of oxidation with release of active oxygen[4].The inhibitory action of hydroxyapatite bound Sodium Tripolyphosphate on adsorption of salivary proteins, makes it an effective agent for inhibiting and removing dental stains[5]. The use of blue-covarine, is a new optical approach to tooth whitening via its ability to change the optical effects of the tooth surface, enhancing the measurement and perception of tooth whiteness[6]. However, the effect of these agents on enamel is not studied enough.

The spectrophotometer is the most suitable device for measurement of how light interacts with materials[7]. Vickers hardness testing is a most reliable method to measure the microhardness of the substrate[8].

Considering all these points, this invitro study was carried out to comparatively evaluate the effect of OTC bleaching products on the color stability and microhardness of enamel.

Materials and Methods

A total of 52 extracted human maxillary and mandibular molar teeth were collected from the department of Oral and maxillofacial surgery, and were selected for the study. Teeth were stored in 0.5% chloramine-T and stored at 4-7°C, immediately after extraction to prevent bacterial growth. All the extracted molar teeth were subjected to removal of calculus, soft debris, if any, using Woodpecker DS ultrasonic scaler. Clean teeth were placed in fresh 0.5% chloramine-T and will be stored at 4-7°C, until use, up to a maximum period of one month, after which the teeth were discarded. Teeth with previous white spot lesions, caries, previous restoration, cracks, fracture, attrition, abrasion, erosion, abrasion were excluded from the study. All the teeth selected for the study were subjected to aqueous staining media consisting of coffee (Nescafe 7.7 g) at 50°C in an incubator for 4 days. After that the roots of all the teeth were separated from the crown portion using a diamond saw in a low-speed precision cutting machine and individually embedded in 6mm thick polyvinyl chloride (PVC) molds using clear self-cure orthodontic resin leaving the outer enamel surface uncovered by the resin. Each tooth was subjected to UV light spectrophotometer to measure the L*a*b* color parameters and Vickers microhardness test (VHN) to record the microhardness of surface enamel. Then the teeth were randomly divided into 4 groups.

Table 1: Teeth whitening products tested in the study.

Group / Tooth whitening agents	Composition	Delivery method/ Duration of use
Group A: Dent 91 anti-stain expert toothpaste	Aqua, sorbitol, silica, xylitol, nanohydroxyapatite, glycerine, sodium hexametaphosphate, titanium dioxide, sodium saccharin	Toothbrush/ Toothbrushing once daily for 2 min for 28 days
Group B: iWhite supreme toothpaste	Fluoride ions; iWhite technology with peroxy-caproic phthalimido acid; Active micropearls technology	Toothbrush/ Toothbrushing once daily for 2 min for 28 days
Group C: Colgate visible white toothpaste	Silica, sorbitol, glycerine, polyethylene glycol, pyrophosphate, sodium tripolyphosphate,	Toothbrush/ Toothbrushing once daily for 2 min for 28 days
Group D: Closeup diamond attraction toothpaste	tetrapotassium pyrophosphate, sodium lauryl sulphate Sorbitol, Hydrated silica PEG-32, Lauryl sulphate, sodium fluoride, blue covarine blue light technology	

Mounted teeth were subjected to group A, group B, group C & group D using soft bristle toothbrush once daily for 2 minutes.

Color Measurement

The color of the specimens was recorded using International Commission on Illumination (CIE) L*a*b* parameters at baseline (T0), one day (T1) and one month (T2) post-treatment using spectrophotometry. On L*a*b* coordinates, the CIE system is a chromatic value color space that measures both value and chroma: L* is

the color`s lightness or darkness (100: white; 0: black); a* is the color`s red (a*>0) and green (a*<0) dimension; and b* is the color`s yellow (b*>0) and blue (b*<0) dimension. Three readings were obtained from each specimen and average was calculated. The color change of specimens at T1 and T2 with respect to baseline (T0) was calculated.

Surface Microhardness

The Vickers hardness number (VHN) of specimen was measured using a microhardness tester for the four experimental groups mentioned earlier. For each specimen, three indentations were made on the enamel surface, with a distance of 200µm between them. The VHN measurements were made in each specimen at baseline (T0), after one day post-treatment (T1) and after one month(T2) post-treatment bleaching application.

Statistical Analysis

Data were collected by using a structure proforma. Data were entered in MS excel sheet and analyzed by using Statistical Package for the Social Sciences (SPSS) software. Quantitative data were expressed in terms of Means and Standard deviation. Difference between mean of more than four groups were compared using one-way ANOVA test. The Comparision between the groups were analyzed using Post-hoc Tukey`s test. Difference between means of four groups were compared using independent t-test. A p value of <0.05 were considered as statistically significant whereas p value <0.001 were considered as highly significant.

Results

The mean and standard deviation of L*, a*, b* color parameters for the study groups are presented in table 2. The results showed that there was significant difference (p<0.05) in the groups containing sodium hexametaphosphate, phthalimido-peroxy-caproic acid, sodium tripolyphosphate & blue covarine; where sodium hexametaphosphate containing toothpaste (Group A) showed significantly highest whitening effect and there was reduction in enamel surface microhardness in sodium hexametaphosphate as shown in table 3.

Table 2: Comparison of ΔL, Δa and Δb between Group A, Group B, Group C and Group D on Day 1 and Day 28.

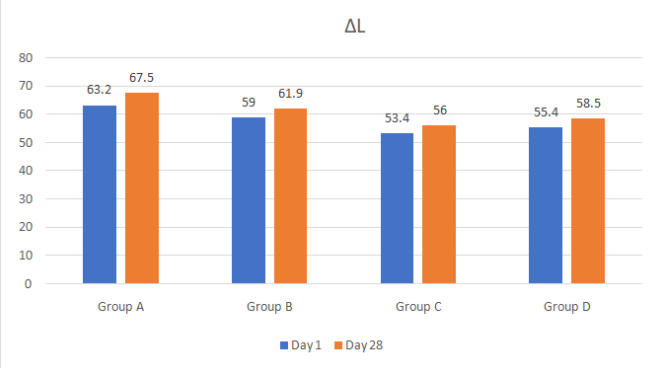
Color Parameters	Mean ± Standard deviation			
	Group A	Group B	Group C	Group D
T1				
ΔL*	63.2 ± 1.71	59 ± 1.38	53.4 ± 1.52	55.4 ± 1.18
Δa*	3.94 ± 0.54	4.63 ± 0.54	8.13 ± 0.35	6.86 ± 0.44
Δb*	8.33 ± 0.45	8.64 ± 0.50	11.02 ± 0.32	10.18 ± 0.43
T2				
ΔL*	67.5 ± 1.38	61.9 ± 1.22	56.07 ± 1.48	58.53 ± 1.50
Δa*	3.71 ± 0.38	3.80 ± 0.38	6.89 ± 0.50	6.04 ± 0.51
Δb*	7.56 ± 0.34	8.15 ± 0.49	10.16 ± 0.45	9.13 ± 0.42

*statistical significance at p<0.05

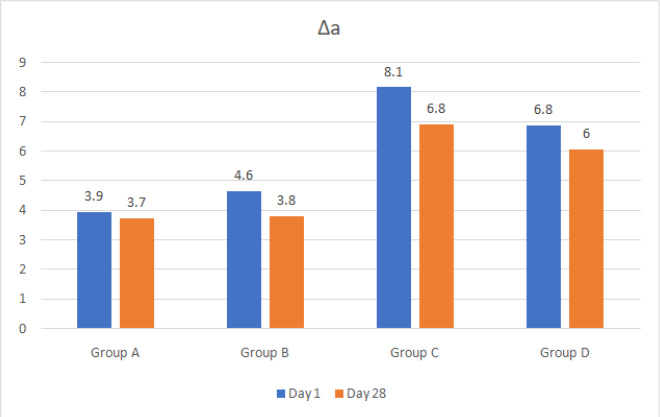
Table 3: Comparison of Microhardness between day 1 and day 28 in Group A, Group B and Group C and Group D.

	Days	N	Mean	Std. Deviation	t value	p value
Group A	1 day	13	294.3846	8.13980	6.727	**<0.001***
	28 days	13	315.0769	7.53283		
Group B	1 day	13	220.1538	17.87385	7.828	**<0.001***
	28 days	13	264.3846	9.77700		
Group C	1 day	13	199.4615	9.89626	6.107	**<0.001***
	28 days	13	221.5385	8.48150		
Group D	1 day	13	180.3846	9.26048	11.234	**<0.001***
	28 days	13	217.3846	7.43347		

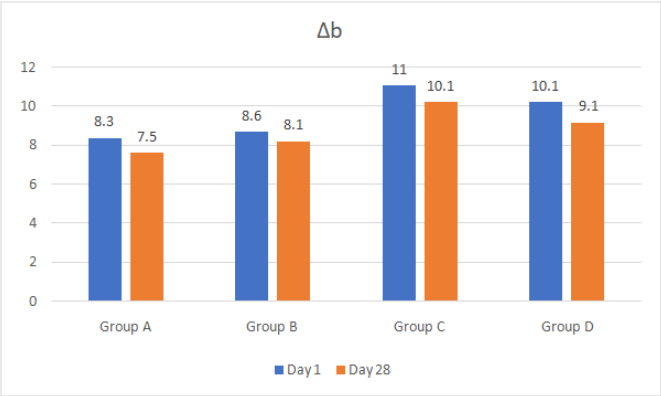
*statistical significance at p<0.05



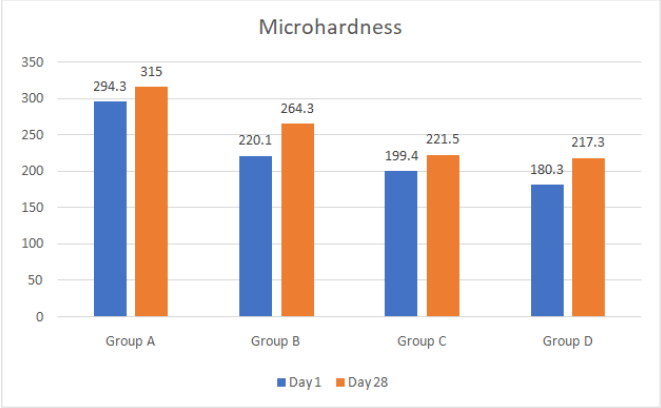
Graph 1



Graph 2



Graph 3



Graph 4

Discussion

To whiten discolored teeth, tooth whitening procedures have become the most conservative and popular procedure[1,9]. Now a days many over-the-counter, at-home, in-office tooth whitening products are available with successful outcomes. However, the lack of research for OTC products could affect the outcome when compared with supervised use of gold standard 10% carbamide peroxide home whitening regimens[10,11,12,13]. Thus, the aim of current study was to compare the effect of non-carbamide peroxide over-the-counter bleaching products on tooth whitening and microhardness on enamel surface.

The color changes during the tooth whitening can be measured by shade guide, digital photography, colorimeters and spectrophotometers. In this study a spectrophotometer was used to measure the accurate and objective color values in the CIELAB color system[4,14].A positive ΔL value after whitening means the teeth tend towards white; negative values of Δa indicates teeth tend to be less yellow and Δb indicates teeth tend to be less red. The distribution of ΔL, Δa, and Δb obtained in this study indicated that the L* values increased, while the a* and b* values decreased[3].

The changes in microhardness of enamel surface are related to its loss or gain of minerals and the changes of organic composition. Microhardness test was chosen as a fast and simple test with reliable outcomes to assess the minor changes resulted after the mineral loss or gain[15,16]. In this study, four different OTC teeth whitening products were tested. Peroxide based products may induce side effects such as bleaching sensitivity and damage of the organic matrix of enamel and dentin, however, biomimetic polyphosphates can be used on daily basis without any adverse effects. The results found in this in vitro study, imply that OTC products, can only act as mild whitening agents in the short run, detaching chromophore substances from superficial dental tissues and causing breakdown of extrinsic stains[4].Sodium hexametaphosphate showed highest whitening effect. Extrinsic stains are usually negatively charged molecules which have an affinity for positively charged calcium ions Ca^{2+} of enamel. Ntovas et al

(2021) reported that sodium hexametaphosphate, a negatively charged molecule with strong affinity for calcium, competes with stain molecules for enamel binding site. In the beginning, it disrupts the pellicle and removes extrinsic stains and subsequently binds strongly with enamel calcium ions and the newly form pellicle, thus preventing new stain chromogen adsorption[7,11-20]. Sodium hexametaphosphate showed highest surface microhardness when compared with other groups. Sodium hexametaphosphate seems to be related to the formation of barrier on the enamel surface against mineral loss. It also remineralizes damaged enamel and strengthen the teeth structure. This will lead to teeth regaining their natural white color, as well as prevention of tooth sensitivity[1,21,22]. Group B which contains phthalimido-peroxy-caproic acid also showed relatively increased whitening effect as it is a synthetic organic peroxy acid derived from caproic acid and phthalimide has a high potential of oxidation with release of active oxygen. Its activity is not based on the release of hydrogen peroxide[7].Sodium Tripolyphosphate (STP) is a linear condensed phosphate and is commonly incorporated in whitening toothpastes for effective stain removal. Its mild chelating properties interfere with stained pellicle integrity. The inhibitory action of hydroxyapatite bound sodium tripolyphosphate on adsorption of salivary proteins, makes it an effective agent for inhibiting and removing dental stains. Sodium tripolyphosphate proved effective in whitening the teeth[5].Blue-covarine silica based whitening toothpastes had less effectively removed extrinsic stain after 4 weeks when compared with other groups. However, the effect of these agents on enamel is not studied enough.

The present study had few limitations. The application of the whitening products followed by manufacturer`s recommendation; however, it was under controlled laboratory conditions. While using OTC products, the lips, cheek, tongue and saliva could reduce the product contact with the teeth. However, the present study could not replicate those clinical conditions. The specimens selected in this study were stained in external environment. However, this cannot be controlled in a clinical environment and may produce a variation in the obtained color.

Conclusion

Within the limitation of this in vitro study, it can be concluded that among the experimental group, sodium hexametaphosphate containing toothpaste showed significant whitening effect than other over-the-counter whitening products. Also, there was reduction in enamel surface microhardness with toothpaste containing sodium hexametaphosphate followed by phthalimido-peroxy-caproic acid, sodium tripolyphosphate & blue covarine. The effectiveness and safety of OTC whitening products should be confirmed so that the public can purchase and use such products.

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