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SURFACE ROUGHNESS EVALUATION AND WHITENING EFFICIENCY ON TOOTH ENAMEL AFTER USING WHITENING TOOTHPASTE: A RANDOMIZED DOUBLE-BLINDED STUDY

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Abstract

The aim of this randomized double-blinded study was to evaluate the enamel surface roughness and color change after one month of whitening toothpaste use and the color stability obtained 1 month after its interruption. 30 volunteers were divided into 3 groups (n = 10) corresponding to the dentifrices: 1) Colgate Total 12 Clean Mint (TD) (Control), 2) Colgate Luminous White (LW) and 3) Sensodyne Whitening Extra Fresh (SB). The volunteers were impression with addition silicone to obtain an epoxy resin replica of the upper central incisor for the initial surface roughness evaluation using a profilometer and the initial color of the incisors and canines was evaluated with a spectrophotometer after one week of wash-out. After 1 month, the color of the central incisors and canines was measured again, and the volunteers were molded to obtain a second replica to the final roughness analysis. Data were submitted to ANOVA-one way ($p \leq 0.05$). The results showed that there was no statistical difference between the dentifrices for color difference and surface roughness for all the studied conditions. It was possible to conclude that the whitening dentifrices used in this study were not able to alter the initial color of the teeth and did not cause changes in the surface roughness of enamel.

Keywords: Color. Dentistry, Operative. Esthetics, Dental. Tooth.

1. Introduction

The tooth color is influenced by intrinsic and extrinsic factors (Greta et al. 2018; El Mourad et al. 2021). The intrinsic characteristics are determined by the light reflection and absorption properties of the enamel and, mainly, the dentin (Vaz et al. 2019). The extrinsic characteristics are related to pigments incorporation within the acquired pellicle and enamel tooth surface (Al-Omiri et al. 2018; Farawati et al. 2019). The incorporation of these pigments is related to factors such as poor oral hygiene, smoking, beverages ingestion such as tea, coffee, wine, among others (Khan et al. 2014; Greta et al. 2018; Farawati et

al. 2019). In order to remove this kind of pigmentation, whitening dentifrices were introduced into the market (Epple et al. 2019).

The whitening toothpaste has solid abrasives, humectant, thickening agents, surfactant, fluoride, pacifying agents and buffering agents (Vaz et al. 2019). This composition is similar to non-whitening dentifrices, however whitening dentifrices have more abrasives and may contain peroxides in its formula (Carey 2014).

The abrasives most commonly used in toothpastes are hydrated silica, calcium carbonate, dicalcium phosphate dehydrate, calcium pyrophosphate, alumina, perlite and sodium bicarbonate (Ganavadiya et al. 2014), which removes extrinsic stains. During tooth brushing, the abrasive particles are trapped between the toothbrush bristle and the stained tooth surface (dos Santos et al. 2019). Since the particle is harder than the stain, the stain is removed for the teeth surface (Vaz et al. 2019). However, in interproximal surface and malocclusion areas, the efficiency of these products are compromised by the difficult access of the toothbrush (Vaz et al. 2019).

Although these dentifrices are efficient on removing extrinsic stain, their abrasion could cause gingival recession, cervical abrasion, dentin hypersensitivity (Veitz-Keenan et al. 2013) and excessive dental wear (Liporoni et al. 2020), mainly when applied with whitening treatments (Azrak et al. 2010; Engle et al. 2010; Paula et al. 2010). Each toothpaste has a RDA (Relative Dentin Abrasivity) value which influences on the enamel and restoration surface roughness (Rosa et al. 2016). Since it is not possible to evaluate the outcomes of whitening toothpastes continuous use on the tooth surface, an epoxy resin replica may be an effective indirect method to evaluate the effects of these products on the enamel surface. The population easily obtains these dentifrices, and the manufacturer advertises on the label that the aim of these products is to bleach which can lead to a frequent or even continuous use of whitening toothpastes without clinical evidence. Nevertheless, there are few clinical trials that evaluate the safety and efficacy of these products on its whitening capability and dental and restoration wear caused by their continuous use without dentist supervision.

The objective of this study was to evaluate quantitatively the surface roughness and color difference caused by whitening dentifrices after one month follow-up and the color stability after one month without using these toothpastes. The null hypotheses were: 1) there would be no color difference; 2) there would be no surface alteration after one month using whitening dentifrices.

2. Material and Methods

This was a local randomized double-blind placebo free study conducted in Brazil. The Institutional Ethics Research Committee approved this research (CAAE – 1659416.9.0000.5418). Also, the project was approved on the clinical trial platform (ensaiosclinicos.gov) under number RBR-4nq793. The volunteers of this study were selected by the inclusion and exclusion criteria and signed the Participation Consent containing all the information for this study. This study was performed in the institution clinic.

The inclusion criteria for this research were: volunteers between 18 and 30 years old, independent of gender, with no periodontal disease and caries free, that never bleached their teeth, have no systemic disease, and no anterior teeth restoration. The exclusion criteria included volunteers with: natural white teeth (B1 or A1 in Vita Classical scale, VITA, Bad Säckingen, SWZ); poor oral hygiene; allergies to any of the products; chronic medicine needs; smoking habits; drugs addiction; caries lesion; extensive posterior restoration; and pregnant women.

The materials used on this research are described in Table 1.

On the first appointment, the volunteers had their supragingival calculus removed, posterior teeth restoration polish, pumice prophylaxis, and oral hygiene instruction was performed. They received the non-studied and non-whitening dentifrice (Sorriso Dentes Brancos, Colgate-Palmolive Industrial LTDA, São Bernardo do Campo, SP, Brazil) and a toothbrush (Colgate Twister, Colgate-Palmolive Industrial LTDA, São Bernardo do Campo, SP, Brazil) and were instructed to brush their teeth three times a day during a week before the beginning of the study - wash-out. After that, the toothpaste was taken, and they received the toothpastes of this experiment. There was no restriction on the volunteers' diet.

Table 1. Materials used on this in vivo study to evaluate the effect of whitening dentifrices on surface roughness and color difference on enamel surface.

DENTIFRICE	COMPONENTS	RDA (Relative Dentin Abrasion)	MANUFACTURER
Colgate Total 12 Clean Mint	Sodium Fluoride (1450ppm), Triclosan 0,3%, Aqua, Hydrated Silica, Glicerin, Sorbitol, Sodium Lauryl Sulfate, PVM/MA, Copolymer, Carrageenan, Sodium hydroxide, Sodium Saccharine, Titanium Dioxide	68	Colgate-Palmolive Industrial LTDA. São Bernardo do Campo, SP – Brazil
Colgate Luminous White	Sodium Fluoride (1100ppm), Aqua, Hydrated Silica, Glicerin, Sorbitol, Pentasodium Triphosphate, PEG 12, Tetrapotassium, Pyrophosphate, Sodium Lauryl Sulfate, Cellulose Gum, Polyethylene, Cocamidopryl Betaine, Xanthan Gum, Sodium hydroxide, Sodium Saccharine, Titanium Dioxide, Blue 1 Lake	175	Colgate-Palmolive Industrial LTDA. São Bernardo do Campo, SP – Brazil
Sensodyne Branqueador Extra Fresh	Sodium Fluoride (1384 ppm), Potassium Nitrate 5%, Sorbitol, Aqua, Silica, Glycerin, Pentasodium Triphosphate, Polyethylene Glycol, Titanium Dioxide, Sodium Methyl Cocoyl Taurate, Cocamidopropyl Betaine, Xanthan Gum, Sodium Hydroxide, Sodium Saccharin	75	Glaxosmithkline Brazil LTDA SA, Rio de Janeiro, RJ, Brazil

A dentist that did not participate on this research randomly divided the volunteers according to a manual randomization method on their experimental groups (n=10): Group 1: Colgate Total 12 Clean Mint (TD) (control); Group 2: Colgate Luminous White (LW); Group 3: Sensodyne Branqueador Extra Fresh (SB). The same dentist removed the toothpastes from their original tubes and allocated them in tubes with code marks in a way that neither volunteer or researcher knew the group each volunteer was allocated - randomized double-blinded experiment.

Volunteers were molded with addition silicone impression material (Express XT, 3M ESPE, Sumaré, SP, Brazil) to obtain an epoxy resin model of the upper central incisor for surface roughness analysis. This procedure was performed at the same day they received their group's toothpastes. It was also performed a mold (Express XT, 3M ESPE, Sumaré, SP, Brazil) from the superior anterior teeth which was used as a guide for the spectrophotometer equipment in a way tooth color was always analyzed at the same point and then first color data of the upper central incisors and upper canines was collected.

After one month, a new color evaluation was performed, and the volunteers were molded to obtain a new model for the final surface roughness analysis. The experiment toothpastes were taken, and the volunteers received the same non-whitening dentifrice used for the wash-out phase. After another month, the final color data was obtained to observe the final teeth color aspect.

The color data was obtained by a spectrophotometer (VITA Easyshade Advance, VITA, Bad Säckingen, SWZ). The color analysis was performed before the whitening toothpaste distribution, one month after using them and one month after their interruption for both upper central incisors and both upper canines using CIELab system. The color difference (ΔE) was determined by the formula: $\Delta E=[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$. The data was determined by the means of central incisors and means of canines for each volunteer. For statistical analysis, the mean of central incisors and mean of canines were separately analyzed.

For surface roughness analysis, an area of $25mm^2$ was determined in the center of the vestibular surface of the right central incisive epoxy resin model using a precision paquimeter (Mitutoyo Sul Americana LTDA., São Paulo, SP, Brazil). The models were obtained before and one month after using the experimental group's toothpastes. The models were set in a metallographic precision cutter (Isomet 1000, Buehler Ltd., Lake Buff, IL, USA) where they were cut by a high-concentration diamond disc (Extec Corp., Enfield, CT, USA) under constant irrigation. This process resulted in 5x5mm squares which had their palatine surface hand planned by a 400-grit silicon carbide sandpaper (3M 411Q, Sumaré Brazil, SP, Brazil). The samples were then taken to ultrasonic bath for 10 minutes to debris removal. After that, the samples were placed in a dry closed tube until the surface roughness analysis was performed.

The samples were analyzed using a profilometer (Dektak 150 Surface Profiler, Bruker, Atibaia, SP, Brazil) in three equidistant regions. It was performed in a 100 µm extension for 10 seconds to obtain the surface roughness mean (Ra).

For statistical analysis, the data were submitted to ANOVA-one way with 5% probability.

3. Results

Color difference

Central Incisors: The ANOVA-one way did not show statistical difference for color difference on this study periods to central incisors (p=0.7843) (Table 2).

Canines: The ANOVA-one way did not show statistical difference for color difference on this study periods to canines (p=0.6130) (Table 3).

Table 2. Result of color difference (ΔE) in incisor teeth for whitening dentifrices.

	INCISOR	
Group	Before the intervention (T1)	After intervention (T2)
	Means (SD)	Means (SD)
TD	1.52 (±0.73)	1.55 (±0.91)
LW	1.17 (±0.65)	1.20 (±0.52)
SB	1.17 (±0.56)	1.29 (±0.82)

No difference for any comparison (p=0.7843). TD: Colgate Total 12 Clean Mint; LW: Luminous White; SB: Sensodyne Whitening Extra Fresh.

Table 3. Result of color difference (ΔE) in canine teeth for whitening dentifrices.

	CANINE	
Group	Before intervention (T1)	After intervention (T2)
	Means (SD)	Means (SD)
TD	1.26 (±0.56)	1.49 (±0.56)
LW	1.48 (±0.71)	1.49 (±0.69)
SB	1.27 (±0.61)	1.68 (±0.40)

No statiscal difference for any comparison (p=0.6130). TD: Colgate Total 12 Clean Mint; LW: Luminous White; SB: Sensodyne Whitening Extra Fresh.

Surface roughness analysis

The ANOVA-one way did not show statistical difference for surface roughness test between the studied groups (p=0.3314) (Table 4).

Table 4. Result for surface roughness (Ra) test for whitening dentifrices.

Group	Before intervention (T1)	After intervention (T2)
	Means (SD)	Means (SD)
TD	1308.8 (±462.1)	1520.3 (±459.8)
LW	1173.2 (±540.4)	1217.6 (±526.7)
SB	1448.6 (±634.0)	1733.1 (±835.6)

No statiscal difference for any comparison (p=0.3314). TD: Colgate Total 12 Clean Mint; LW: Luminous White; SB: Sensodyne Whitening Extra Fresh.

4. Discussion

Toothpaste contains solid abrasives, humectants, thickening agents, fluoride and other components on their formulation (Vaz et al. 2019). The whitening toothpastes possess basically the same composition and are thus classified by the ability to remove pigments and prevent extrinsic stain formation (Rosa et al. 2016). However, these toothpastes show in their label that they are able to produce whitening effects which was not observed on this study as the statistical analysis showed no difference between the groups confirming the first null hypothesis. Only whitening dentifrices based on silica abrasive as whitening

component were studied in order to evaluate their efficiency and compare with a control silica-based dentifrice, and thus avoiding comparison between different abrasive types and focusing only in quantity of abrasives.

Whitening effect of dentifrices is associated to the quantity of abrasives on their formula (de Moraes et al. 2015), and for this reason the whitening dentifrices have more abrasives when compared to conventional non-whitening dentifrices (Alshara et al. 2014). In this study there was no statistical difference between the control toothpaste and the whitening ones, and this probably happened because all dentifrices have abrasive on their formula. In other words, the quantity of abrasives on the whitening dentifrices of this study was not able to promote the dental whitening. The abrasive was the same for the 3 toothpastes and this low alteration was not able to change the tooth color. In addition to this, there is no study that justifies the use of abrasives as whitening agents. To obtain a whitening effect, bleaching agents, such as hydrogen peroxide or carbamide peroxide, are used (Borges et al. 2015), and its efficiency depends on the time of exposure and concentration on the tooth surface (Borges et al. 2014; Mosquim et al. 2017). The medicine control government agencies should request the label and advertisement changes of these products, so the consumer does not use a whitening dentifrice when not indicated.

The second null hypothesis of this study was accepted, as there was no statistical difference on surface roughness between the groups. Toothpaste's abrasion is influenced by size, shape, hardness and concentration of the abrasive particle (Nakamura et al. 2015). In this study all groups were silica based which probably justifies the results. Silica based dentifrices are less abrasives when compared with other types of abrasives (Pascaretti-Grizon et al. 2013; Alencar et al. 2016), and probably for this reason there was no increase of surface roughness after teeth brushing with these toothpastes. Another hypothesis that may justify this result is the saliva exposure to the tooth surface. The deposition of calcium, phosphate and fluorine ions of the saliva probably worked as a protective effect preventing tooth wear (Hara and Zero 2014; Casado et al. 2018). Another important factor is the previous guidelines and practice of hygiene and brushing, in addition to the use of a pre-defined brush may also have contributed to the results found for roughness. Using whitening dentifrices for more than 1 month could, hypothetically, interfere with enamel surface wear or color change (Simões et al., 2020; Torres et al., 2020). In addition, the exclusion factor in this study (poor oral hygiene, chronic medicine needs, smoking habits, drugs addiction) may be a methodological limitation, because when excluding these participants, the tendency was to add patients with less risk of pigmentation and color change.

In this study it was obtained epoxy resin replicas of sound tooth surfaces in order to analyze the surface roughness. Due to the quantity of irregularities on the surface teeth, it was impossible to realize the roughness test in the entire vestibular surface. To work around this problem, a 25mm^2 area was determined at the exact center of the vestibular surface where the surface roughness was analyzed in 3 plane equidistant regions. As there are anatomic differences between the volunteers, the measurement was not in the same point for all samples, but always in the delimited area. The surface roughness evaluation through replicas showed a valid methodology as it allows the analyses of the surface tooth close to a clinical reality.

5. Conclusions

Based on this study's results, the whitening toothpastes were not able to promote dental whitening and changes on enamel surface roughness after one month.

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