

EFFECT OF NOVEL WHITENING TOOTHPASTES ON THE SURFACE ROUGHNESS, MICROHARDNESS, AND COLOR STABILITY OF ANTERIOR EXTRA BLEACH WHITE (XBW) COMPOSITE: AN IN-VITRO STUDY

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ABSTRACT

Aim: The current study investigated the effect of three different whitening tooth paste on surface roughness, microhardness and color stability of Gænial Anterior Extra Bleach White (XBW) composite resin.

Materials and Methods: Total of 42 composite resin discs were prepared using a split Teflon mold. The specimens were distributed to 3 different groups (n=14). The specimens of each group were brushed with different whitening toothpaste. First group (C1), toothpaste containing charcoal (CURAPROX), second group (C2), toothpaste containing blue sapphire (CLOSEUP GOLD WHITE NOW) and third group (C3), toothpaste containing diamond powder and gold nanoparticles (SPLAT SPECIAL GOLD TOOTHPASTE). Surface roughness, microhardness and color stability of the tested samples were assessed before and after simulated tooth brushing and immersion in coffee. Shapiro-Whilk test and Levene's test used to test normality and homogeneity. One way ANOVA test was used to compare several groups followed by Tukey's post hoc test. t-test were used for intragroup comparisons.

Results: Whitening toothpaste containing charcoal showed the worst roughness after simulated tooth brushing and immersion in coffee. Surface hardness decreased in all groups, but whitening toothpaste containing diamond and gold nanoparticles showed nonsignificant best microhardness readings and significantly better color stability

Conclusions: It was concluded that whitening toothpaste containing diamond and gold nanoparticles showed promising color stability with acceptable surface roughness and microhardness with anterior Extra Bleach White (XBW) composite. However, additional clinical studies are essential to confirm these results.

KEYWORDS: Whitening toothpastes, surface roughness, microhardness, color stability, Charcoal, Diamond, Gold, blue sapphire pigments, Extra Bleach White (XBW) Composite resin.

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INTRODUCTION

Many patients are not pleased with the natural tooth shade, and they favor their teeth to be whiter than the whitest natural teeth which can be attained by recent bleaching agents^{1,2}. Extra white shade resin composites have been lately introduced by many manufacturers to restore bleached teeth. The color stability of those extremely white teeth shade composite restorations is very important for the patients seeking those peculiar shades³.

Poor oral hygiene, staining foods, beverages and smoking may lead to external teeth discoloration. Dental staining reduces self-confidence and causes clumsiness and public difficulties which is emotionally destructive⁴.

Whitening toothpastes usually used to remove extrinsic stains and to maintain the whiter appearance of teeth. Whitening toothpastes usually contain abrasive particles which have a significant role in removing stains, bacteria and cleaning teeth and restoration's surfaces. Dentifrices filled with large amount of abrasives may cause injury to soft tissues, hard tissue, restorations and may leads to gingival recession, cervical wear and teeth hypersensitivity⁵.

One of the most popular whitening toothpastes is those containing charcoal. Activated charcoal with high porosity attaches to tooth surfaces and eliminate coloring agents by the ability of its nanopores to adsorb chromophores, stains and pigments from the tooth surfaces. In addition, Charcoal helps tooth whitening through tooth abrasion^{4,6,7}.

Another abrasive based toothpaste recently introduced in the market is Diamond and Gold containing toothpastes, which are claimed to achieve enhanced cleaning action compared to conventional toothpastes, while preserving the tooth substance. Using fine particles of diamond and gold powder as an abrasive is biologically and toxicologically safe. They claim to be easily capable of polishing and bleaching teeth. The effects of diamond and gold nanoparticles have not so far been carefully investigated⁸.

Studies reported that the color shift from yellow to blue produces an enhancement in the observation of tooth whiteness⁹. Newly introduced Whitening toothpaste (CLOSEUP GOLD WHITE NOW) containing blue sapphire pigments toothpaste for whitening teeth three times immediately, its formula works just like color-correcting cosmetics to neutralize yellow, boosting the whiteness of enamel tone to create a unique shade of white instantly. The manufacturers claim that it is zero abrasive formula that whitens teeth without damage to enamel, restorations or increased sensitivity.

The whitening toothpastes abrasion potential on tooth surface and restorations and cleaning efficacy, is mainly based on the included abrasive, its particle size, shape, hardness and concentration within paste. Highly abrasive particles may lead to better cleaning efficiencies. It has been shown that toothpastes with a very good cleaning ability often irritate higher roughness and abrasive wear on tooth surface and restorations^{7,10,11}.

Surface roughness, micro hardness and color stability are significant features responsible for the durability of composite resin restorations. Restorative materials with high surface roughness and low micro hardness are susceptible for indentations and scratches which may leads to color instability and total failure of the restorations^{12,13}.

Bleach shade composites are luminous and more translucent than ordinary shades, they have lower translucency and higher masking ability. Lately there is an increased demand to use bleach shade composites, as patients request high aesthetic levels, and they are similar to tooth whitening treatment modalities³.

According to our knowledge, no studies were conducted to evaluate the effects on bleach-shade composite caused by various whitening dentifrices which allows us to theorize that there is no data regarding the effect of whitening toothpaste on the surface roughness, micro-hardness and color changes of aged bleach shade composites resin.

Therefore, the aim of the current study was to evaluate the effect of novel whitening toothpastes on the surface roughness, micro hardness and color stability of anterior Extra Bleach White (XBW) composite.

The null hypothesis of the study was that addition of whitening particles to toothpastes will not alter the surface roughness, microhardness and color stability of Extra Bleach White (XBW) Composite resin.

MATERIALS AND METHODS:

Sample size calculation was done using G*Power¹⁴ version 3.1.9.7. Calculations were based on the results of some former studies, the predicted total sample size (n) was found to be (42) samples (i.e. 14 samples per group). Approval to this study was agreed by Research Ethics Committee at the Faculty of Dentistry, October 6 University, Giza, Egypt, with approval number: RECO6U/1-2023

A total of 42 Gsænial Anterior Extra Bleach White (XBW) Composite resin specimens (6 mm width * 3mm thickness) were prepared by a split Teflon mold which was positioned on a glass slab and covered with Mylar strip. Composite resin was applied in the mold, another Mylar strip was then applied, and pressed under glass slide to push out extra material and to achieve horizontal flat surfaces. The specimens were light cured at zero distance from glass slab, for 20s using LED light curing unit (Premium plus, light intensity 1200 $\mu\text{m}/\text{cm}$). The bottom of the specimen was labeled with a small indentation. Then specimens were kept for 24 h in distilled water before testing.

Random distribution of samples was done, into 3 groups (n=14) according to the type of whitening toothpaste used. For the first group (C1), the whitening toothpaste was containing Charcoal (CURAPROX), the second group (C2), the whitening toothpaste was containing Blue sapphire (CLOSEUP GOLD WHITE NOW), (C3) was the third whitening toothpaste containing Diamond powder and Gold nanoparticles (SPLAT SPECIAL GOLD TOOTHPASTE). Table (1).

Surface Roughness measurement

The surface roughness of the specimens was determined by Interferometer Micro-scope SJ-210 surface roughness tester, Mitutoyo, Japan. Five measurements were done on each surface of the specimen in different places. The mean of these five measurements was calculated as roughness value of the specimen. Measurements were done before and after simulated tooth brushing and immersion in coffee¹⁵.

Microhardness testing

The specimens were tested for micro hardness using Vicker's Hardness tester, Wilson hardness tester model TUKON 1102, Germany. Three indentation tracing were made across the center of each specimen. The mean of these three measurements were determined as micro hardness value of each specimen. Measurements were done before and after simulated tooth brushing immersion in coffee.

Color stability measurement:

A spectrophotometric measurement was done to record the color stability (ΔE) of the specimens before and after simulated tooth brushing and immersion in coffee (Nescafe) for 14 days.

VITA Easy shade (VITA Zahnfabrik H.Rauter GmbH & Co KG) was used for the color measurement of the specimens using CIE ($L^*a^*b^*$). Color change was recorded by calculating the degree of color difference between different groups. The measurements were calculated as stated by the following equation¹⁶:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Simulated tooth brushing:

A custom-made machine (figure 1) was fabricated to simulate brushing mechanism, developed. The machine is classified as a reciprocating machine, which transforms rotational motion to linear motion. The back-and-forth motion of the machine was transmitted to the tooth brushes through 3 horizontal shafts.

TABLE (1) Materials' Specification, composition, and manufactures:

Material	Specification	Composition	Manufacturer
CURAPROX Black is white	Whitening toothpaste containing charcoal	Activated charcoal, Aqua, Glycerin, Sorbitol, Carbon Black, Hydrated Silica, Argilla, Aroma, Decyl Glucoside, Tocopherol, Mica, Xanthan Gum, Cocamidopropyl Betaine, Sodium Monofluorophosphate, Titanium Dioxide, Hydroxyapatite (Nano), Citric Acid, Potassium Acesulfame, Sodium Benzoate, Maltodextrin, Microcrystalline Cellulose, Potassium Chloride, Potassium Sorbate, Methyl Diisopropyl Propionamide, , Menthyl Lactate, Zea Mays Starch, Stearic Acid, Citrus Limon Peel Oil, Lactoperoxidase, Tin Oxide, Cetearyl Alcohol, Glucose Oxidase, Amyloglucosidase, Potassium Ethyl Mentane Carboxamide Thiocyanate, Sodium Bisulfite, Hydrogenated Lecithin, Limonen, CI75810, CI77289.	SWISS PREMIUM ORAL CARE Curaden Switzerland AG Amlehnstrasse 22 CH-6010 Kriens T+41 (0)41 319 45 50 F+41 (0)41 319 45 90 info@curaden.ch www.curaprox.com
CLOSEUP GOLD WHITE NOW BLUE SAPPHIRE pigments	Whitening toothpaste containing BLUE SAPPHIRE pigments	Hydrated Silica, Aqua, Sorbitol, PEG-32, Sodium Lauryl Sulfate, Laureth Sulfate, Glycerin, Oleic Acid, Aroma, Cellulose Gum, Sodium Fluoride, Mica, Sodium Saccharin, PVM/MA Copolymer, Sodium Lecithin, Caprylyl Glycol, Lauryl Alcohol, Limonene, Trisodium Phosphate, CI 74160, CI74260, CI 77891	UAE Unilever Gulf FZE Jebel Ali, Dubai, UAE P.O. Box 17055 T: 80053837
SPLAT SPECIAL GOLD TOOTHPASTE	Whitening toothpaste containing Diamond powder and Gold	Aqua, Hydrated Silica, Hydrogenated Starch Hydrolysate, Glycerin, Aroma, Cellulose Gum, Capryloyl/Caproyl Methyl Glucamide, Sodium Lauroyl Sarcosinate, Lauroyl/Myristoyl, Methyl Glucamide, Sodium Benzoate, Potassium Sorbate, Vitis Vinifera Seed Extract, Royal Jelly, Xanthan Gum, Stevia Rebaudiana Leaf Extract, Mica, CI 77891, Ananas Sativus Fruit Extract, Sodium Bicarbonate, Lactic Acid, Limonene, Thymol, CI 77491, Calcium Lactate, Maltodextrin, Diamond Powder, Gold. 0.01-10% of gold particles having a particle size of 10-200 micrometers	SPLAT United Kingdom 50 Grosvenor Hill, Mayfair, London, W1K 3QT +371 67133968 info-GB@splatglobal.com
G-aenial Anterior Extra Bleach White (XBW) Composite resin	Nano hybrid composite resin	Methacrylate Monomers Pre-polymerized fillers 16-17 μ Silica containing Lanthanoid and Strontium Fluoride Inorganic filler > 100 nm Silica Inorganic filler < 100 nm Fumed silica, Pigments, Catalysts The matrix: mixture of urethane dimethacrylate (UDMA) and dimethacrylate co-monomers. It is bis-GMA free.	GCAMERICA INC. 3737 West 127th USA - Alsip, Illinois 60803 Tel.+1.800.323.7063 Fax.+1.708.371.5103 http://www.gcamerica.com

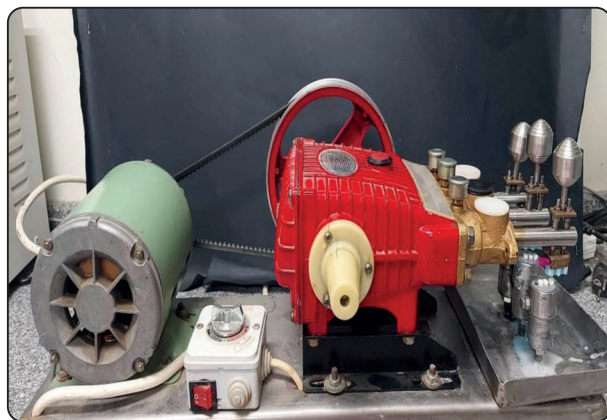


Fig. (1) Photograph of the custom-made tooth brushing simulating machine

A metallic stainless-steel plate was fixed to the base of the machine using two screws. Three cylindrical specimen holders were attached to the metallic base of the plate using 3 screws.

Each specimen holder was provided with a hole in the center with a diameter of 6 mm in and 1.5 mm height to support each specimen during testing, the cylinder was split into two halves that are fixed by a screw, another screw was made at the bottom of cylinder to fix it in the stainless-steel container. Each disk was fixed on cylindrical holder with its surface extending above the level of the specimen holder by 0.5 mm to ensure that the toothbrush (Oral B classic soft, Procter & Gamble, UK) is in contact with the specimen and not the specimen holder.

Hence, the tooth-brushing machine was accomplished with horizontal actions of the toothbrush using a weight of 200 gm and a traveled course of 2 cm. The rotation was 280 cycles/min, the total time of tooth brushing was of 18 min, therefore the total cycles was 5,000 cycles which represents 6 months of tooth brushing. Toothbrush head was substituted with every 10000 cycles, while the slurry mixture (dentifrice, distilled water) was applied by a syringe every 5 minutes of the testing time. In order to resemble tooth brushing in the oral cavity, dentifrice and distilled water were used with ratio 1:1. The specimens were stored in coffee for 14 days until testing microhardness, roughness and color stability.

Data were collected, charted, and statistically analyzed. Numerical data was represented as mean and standard deviation (SD) values. Shapiro-Wilk's test was used to test for normality. Homogeneity of variances was confirmed using Levene's test. Data were normally distributed, and the homogeneity assumption was not violated. Multiple groups comparisons were analyzed using one-way ANOVA test followed by Tukey's post hoc test while intragroup comparisons were analyzed using paired t-test. The significance level was set at $p < 0.05$ within all tests. Statistical analysis was made with R statistical analysis software version 4.1.3 for Windows.

RESULTS

Results of intergroup comparisons for surface roughness presented in table (2), showed that before brushing, there was no significant difference between tested groups ($p = 0.351$). While after brushing the difference was statistically significant with group (III) having significantly lower value than other groups ($p = 0.014$).

For all groups, there was a significant increase of surface roughness after brushing ($p < 0.05$). The change in group (I) was significantly higher than that of group (III) ($p = 0.024$).

Results of intergroup comparisons for surface microhardness presented in table (3), showed that before brushing, there was no significant difference between tested groups ($p = 0.695$). While after brushing the difference was statistically significant with group (III) having significantly higher value than group (II) ($p = 0.039$).

For all groups, there was a significant decrease of hardness after brushing ($p < 0.05$). The change in group (II) was significantly higher than that of group (III) ($p = 0.016$).

Results of intergroup comparisons for color change presented in table (4), showed that there was a significant difference between different groups with group (III) having significantly lower value than other groups ($p < 0.001$).

TABLE (2) Inter and intragroup comparison of surface roughness (Ra)

Interval	Surface roughness (Ra) (Mean±SD)			f-value	p-value
	Group (I)	Group (II)	Group (III)		
Before brushing	0.10±0.03 ^A	0.14±0.06 ^A	0.12±0.05 ^A	1.11	0.351
After brushing	0.71±0.01 ^A	0.70±0.27 ^A	0.44±0.14 ^B	5.45	0.014*
t-value	57.42	3.35	6.03		
p-value	<0.001*	0.015*	<0.001*		
Difference	0.61±0.03 ^A	0.56±0.30 ^{AB}	0.32±0.14 ^B	8.60	0.024*

*Different superscript letters indicate a statistically significant difference within the same horizontal row; *significant (p<0.05)*

TABLE (3) Inter and intragroup comparison of surface hardness

Interval	Surface hardness (Mean±SD)			f-value	p-value
	Group (I)	Group (II)	Group (III)		
Before brushing	36.29±1.06 ^A	36.74±1.84 ^A	36.00±1.80 ^A	0.37	0.695
After brushing	30.95±1.02 ^{AB}	30.25±1.29 ^B	31.88±0.93 ^A	3.91	0.039*
t-value	15.32	10.57	7.64		
p-value	<0.001*	<0.001*	<0.001*		
Difference	5.34±0.92 ^{AB}	6.49±1.62 ^A	4.13±1.43 ^B	5.28	0.016*

*Different superscript letters indicate a statistically significant difference within the same horizontal row; *significant (p<0.05)*

TABLE (4) Intergroup comparison of color change (ΔE)

Color change (ΔE) (Mean±SD)			f-value	p-value
Group (I)	Group (II)	Group (III)		
21.49±1.60 ^A	21.38±4.18 ^A	13.77±1.23 ^B	19.07	<0.001*

*Different superscript letters indicate a statistically significant difference within the same horizontal row; *significant (p<0.05)*

Mean and standard deviation values for surface roughness, surface hardness and color change are presented in figures from (2) to (4) respectively.

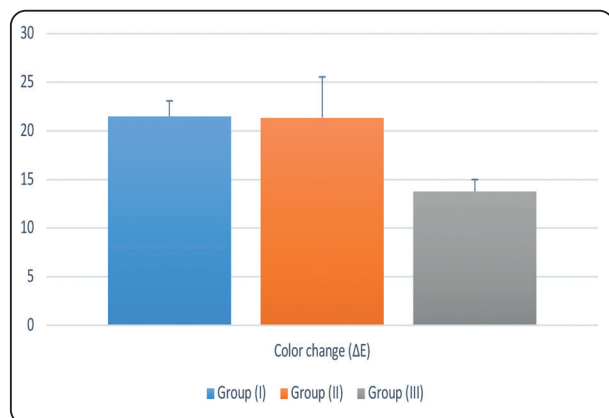


Fig. (4) Bar chart showing mean and standard deviation values for color change

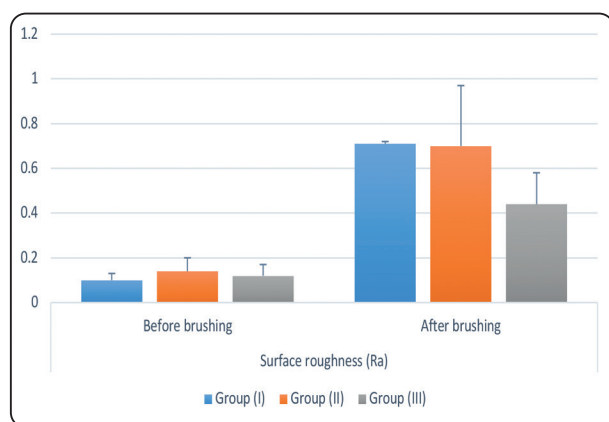


Fig. (2) Bar chart showing mean and standard deviation values for surface roughness

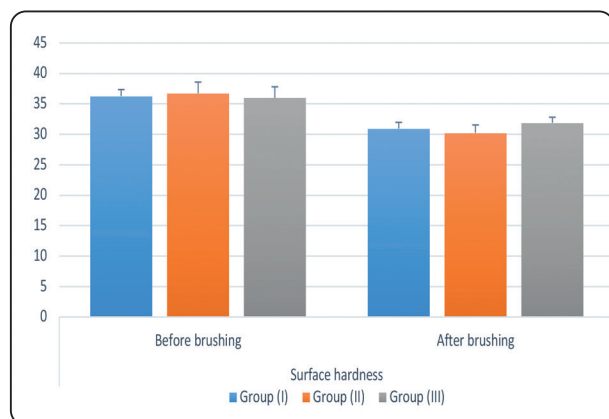


Fig. (3) Bar chart showing mean and standard deviation values for surface hardness

DISCUSSION

Nowadays, dental bleaching is one of the most customary dental services. People are more alert to their look. Dental staining diminishes self-confidence and can cause discomfort and public difficulties and is psychologically critical. Teeth shade alterations can be due to extrinsic and intrinsic discoloration¹⁷.

Bleach shade resin composites have been recently introduced to restore bleached teeth. The color stability of those extremely white teeth shade composite restorations is very important for the patients seeking those bright shades³. We chose to use Gænial Anterior Extra Bleach White (XBW) Composite resin in the current study.

Although an extensive variation of abrasive toothpastes exists, three different types of whitening tooth pastes were used in this study. CURAPROX is one of the most commonly used whitening tooth paste which contain charcoal abrasives

Lately, toothpaste containing blue sapphire (CLOSEUP with BLUE SAPPHIRE) pigments was launched. Blue sapphire is an optical brightener that is said to stick to the tooth surface, capable of causing measurably whitening effect¹⁸.

SPLAT SPECIAL GOLD is a recently introduced whitening toothpastes which contains diamond powder that claimed to offer high cleaning efficacy with low abrasion, Also it contains a Nanogold particles with its unique properties to obtain gentle whitening effect, Nanogold is famous for its excellent caries inhibitory effect by neutralizing the resulting organic acids of oral bacteria¹⁹.

In the current study, reciprocating tooth brushing simulating machine was planned to homogenize amount of toothpaste and technique of tooth brushing. This was a strong point in the current study to mimic the clinical conditions, to minimize variations and give even brushing to all the specimens^{15, 16}.

The minerals contents of the teeth surfaces and the resin matrix of the composite restorations

may be affected by the abrasive particles ratio and activities of the whitening tooth paste which may lead to increase in surface roughness and reducing micro hardness of both, teeth surfaces and composite restorations²⁰. If surface roughness increases, this will lead to greater bacterial colonization and formation of oral biofilm on composite restorations leading to periodontal affection and recurrent caries formations^{4, 21}.

In this study, surface roughness, microhardness and color stability, of Extra Bleach White (XBW) Composite resin, were affected by using different whitening toothpaste so the null hypothesis was rejected. In the current study, whitening toothpaste containing nanogold particles showed the least increase in surface roughness of composite resin if compared to other toothpastes.

Curaprox contains activated charcoal and hydrated silica as the active abrasive ingredient, it also contains nano-titanium dioxide which has additive abrasive effect¹¹. Our results agreed with another findings by Torso et al²², that stated that the abrasive fine particles activated charcoal can remove external stains, but they can correspondingly cause increased surface roughness as pigments and biofilm are taken by pores created by activated charcoal.

Other Authors stated that the abrasive wear produced by toothpastes depends on particle hardness, shape, form, and size. The wear of composite resin cause leaching of filler particles and unpolymerized monomers, which may affect surface roughness, the gloss and aesthetics of esthetic restorations¹³.

For BLUE SAPPHIRE pigments, Yilmaz and Kanik²³, supported our results that the usage of abrasive toothpaste containing BLUE SAPPHIRE pigments may disturb the restoration's surface properties.

Data of a study done by Pune N., et al¹¹, suggested that diamond and nanogold particles in toothpastes can be accustomed in concentration and particle size to fulfill minimal abrasive standards and to be comparable to reference low-abrasive toothpastes.

Regarding the performance of diamond and nanogold particles containing whitening toothpaste, with the best surface roughness display thanks to the unique properties of the extremely small size diamond and nanogold particles. Our results disagree with the findings of Hamza et al⁸ as they assumed that whitening toothpastes that contain traditional abrasives beside diamond and nanogold powder, could lead to additional drop of surface roughness and affect enamel brightness and gloss.

Another important surface property is Microhardness which presents the surface resistance against constant deformation and gives impression about the materials' strength and wear resistance²⁴. The Vickers hardness test is a method testing of surface microhardness.

According to our results, a significant decrease in surface hardness numbers was realized after using different whitening toothpastes that is possibly because the abrasive wear caused shedding out of the resinous matrix showing only fillers on the surface, so the indenter spotted the hardness of the fillers^{16, 22}.

On the other hand, a study done by Farghal et al⁵, concluded that brushing with the tested whitening dentifrices in their study significantly affected the surface roughness and microhardness of composite resins irrelevant to type of whitening toothpaste. Other Previous study also showed no change in microhardness of composites after using with whitening toothpastes²⁴. In contrast to our current results that showed activated charcoal whitening toothpaste to cause significant decrease in surface hardness in comparison to other tested toothpastes.

The results of the study done by Roselino et al²⁵, verified that the wear of resin composites is material related property. Filler shape, size; loading, composition of organic matrix, and bonds between fillers and matrix, as well as the degree of conversion after curing are all factors to be considered.

In this study, we selected coffee as a coloring agent, due to its frequent consumption according to data provided by Soliman et al²⁶, who also

stated that coffee can cause high color changes for composite resin. According to coffee manufacturers, consumers drink one cup of coffee in about 15 min, they usually use 3.2 cups daily. Accordingly, it was assumed that storage of composite specimens in staining solutions for 1 day may simulate 30 days *in vivo*¹⁷. Therefore, storing in coffee for 14 days is simulating a mean of 14 months of coffee consumption.

The method of coffee staining is by adsorption and absorption of its low-polarity yellow stains onto the organic phase of composite, which can penetrate in deep layers of polymer matrix of composite^{27,28}.

After color change measurement, whitening toothpaste containing diamond and gold nanoparticles showed the least color changes with statistically significant difference than other toothpastes.

Manufacturer claimed that SPLAT SPECIAL GOLD TOOTHPASTE is free from parabens, chlorhexidine, saccharin, synthetic dyes, and fluoride. This toothpaste has gentle whitening effect thanks to Gold Powder, Diamond powder, bromelain and silica rounded particles.

The previously mentioned ingredients of SPLAT SPECIAL GOLD TOOTHPASTE can confirm the finding of our study as this type of toothpaste showed the least color change after storage.

Whereas for the other types of toothpastes, the increased surface roughness affected the gloss and color of composite restorations in addition to impairing their aesthetic appearance⁵. pH as some an additional factor may be provided by the natural components of the toothpaste, can also disturb the surface properties, and increase stains absorption on the surface of resin composite.

Our results were consistent with those of Torso et al²², who found that charcoal containing dentifrice promotes extra changes in brightness and color than conventional toothpastes after simulated tooth brushing. They concluded that the softer polymeric organic matrix composite resin may show better

results. On the other hand, whitening toothpaste components, quantity, and structure affect the ability of resin for water sorption in aqueous field.

Supporting our findings, Roselino et al²⁵, stated that resin composite restorations after brushing with silica containing toothpastes, the organic matrix was effortlessly worn out and displayed the fillers, shifting the scattering of light in resin composite that caused change in its brightness. They also concluded that blue pigments initiated a decrease in b^* value.

Meireles et al⁹, mentioned that after toothbrushing blue dyes was placed on enamel surface and, along two weeks of continuous usage, offering an immediate and satisfactory modification in color from yellow to blue, and creating a brighter and whiter visual perception. The efficacy provided using blue pigment is still questionable, as there are some studies stating that these dyes showed no tooth color improvement compared to ordinary ones.

These opinions are contradicted by many other authors^{29, 30} who found that the color alteration of composite samples did not cause a significant change after toothbrushing with toothpaste containing blue pigments. Another study stated that brushing with charcoal whitening dentifrices, showed no difference in color change of composite, indicating that after aging the color change was not detectable after 15 days³¹.

Additional explanation that surfactants in toothpastes might increase the efficiency of its active ingredients. This explanation could justify the minimal color changes of charcoal containing toothpaste on composite after aging^{29, 31}.

Limonene, a main component of essential oil from citrus fruit peels, has revealed great potential in teeth whitening. It may have superior effect on the surface of composite after ageing because of its acidic nature, causing greater ΔE ³¹.

SPLAT SPECIAL GOLD TOOTHPASTE group, contains hydrated silica and sodium hydroxide, and

TiO₂ pigments to correct its pH. Consequently, due to its low quantities of abrasives and higher pH, this group showed the least color shift after ageing^{4,11}.

Gold nano-particles absorb then scatter light with astonishing efficacy due to their strong interaction with light. Gold nanoparticle absorption and scattering properties can be adjusted by adjusting the particles shape, size, and the local refractive index.³²

Color change in composite resin is correlated to water sorption, and the matrix hydrophilicity. Water sorption is the ability of composite resin matrix to absorb water, fluids, and pigment. Therefore, expanded matrix volume promotes higher sorption. Additionally, the low degree of conversion and increased number of unreacted monomers eases greater solubility, and deteriorates stability of color. Under similar circumstances, specific monomers exhibit lower degree of conversion in comparison to others, they are (in ascending order): Bis-GMA< Bis-EMA< UDMA< TEGDMA. Therefore, G-aenial's high color change may be due to dimethacrylate comonomers, G-aenial is bis-GMA free^{16,29}.

Bleach shade composites are lighter shades that may discolor more distinctly than darker ones, the matrix used in these materials has a significant role in color change susceptibility and water uptake²⁷.

Some limitations of our study were that the samples were with flat surfaces while the restorations surface track the normal anatomy of natural tooth. Furthermore, no sufficient information about percentage of toothpaste components and the size of particles, was provided as the manufacturers do not distinctly reveal the constituents of their products³³⁻³⁶.

Similar studies on other composites, with staining products, and accelerated artificial aging are necessary to assess physical, mechanical, and optical changes on restorative materials³¹.

Comparison of our results with other studies is difficult due to using variable methodologies including different toothpastes, composites, the number of cycles, and staining procedures.

CONCLUSION

Within the limitations of the current study, it could be concluded that whitening toothpaste containing diamond and gold nanoparticles showed promising color stability with acceptable surface roughness and microhardness with anterior Extra Bleach White (XBW) composite. Though, studies are required to confirm these results clinically.

Ethics approval

RECO6U/1-2023

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Conflict of interest:

The authors declared no conflict of interests.

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