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EFFECT OF DIFFERENT IN-OFFICE BLEACHING TECHNIQUES ON ENAMEL COLOR AND SURFACE ROUGHNESS: IN VITRO STUDY

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ABSTRACT

Objective: To evaluate and compare the influence of various in-office bleaching agents on enamel color change and surface roughness

Materials and Methods: Sixty human permanent maxillary central incisors were collected and maintained in cylinder plastic mold (1cm height and 2cm width). Teeth were assigned based on the test into two groups; color change test group (n=30), and the surface roughness test group (n=30). Based on the bleaching technique, each group was further assigned into 3 subgroups (n=10) (light activated bleaching agent: Philips Zoom, chemical-activated; Philips Dash and two layer technique chemical activated; Zoom QuickPro). A spectrophotometer was used to measure the enamel color change in each bleaching technique. In addition, a non-contact optical profilometer was used to assess the surface roughness both before and after bleaching. The outcomes for each test were analyzed statistically using Student's *t*-test, one-way analysis of variance (ANOVA) followed by post-hoc tukey. The level of significance was set at $p \leq 0.005$.

Results: Considering the color change measurements, all tested groups after bleaching exhibited statistical significant difference (P=0.0112). The Zoom group had the highest mean values subsequently Dash and Quick pro groups. For the surface roughness results, there was no statistical significant difference of all the tested groups after bleaching (P=0.592).

Conclusions: All the studied in-office bleaching systems had a positive effect on teeth whitening; with the highest whitening potential for the light-activated system in comparison to the chemical-activated and two layer bleaching techniques. The enamel surface roughness exhibited insignificant changes in the different studied systems.

KEYWORDS: Enamel Color, In Office Bleaching, Surface Roughness, Profilometer.

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INTRODUCTION

Nowadays, teeth bleaching are a main line of treatment in office's daily routine, as most people aim to achieve an attractive beautiful white smile. Bleaching of teeth is considered the most conservative esthetic option for tooth discoloration. This provides acceptable and safe results within a short period of time. [1, 2] Vital teeth bleaching can be carried out with two modalities which are at-home and in-office bleaching techniques.[3] Considering the in-office bleaching techniques, they have many advantages as being controlled by dentist, avoiding material ingestion and providing soft tissue protection.[4] The main differences between both techniques are the concentration of the bleaching agent. In office technique can utilize high concentration of bleaching products that promote immediate and faster whitening results. In addition, it may improve patient satisfaction and motivations.[5]

Current bleaching agents are relied mainly on hydrogen peroxide (HP) or carbamide peroxide. Teeth whitening mechanism are based on the large chromophore molecule oxidation. These molecules are considered the main cause of tooth structure discoloration.[6] The low HP molecular weight and dental structure's permeability permit access for the bleaching agent through tooth structure's organic matrix. The HP decomposition produces perhydroxyl and oxygen free radicals. After that, the staining molecules are oxidized and cutting the long chains organic molecules into a colorless short chains causing teeth whitening.[7, 8]

There are various methods to enhance the bleaching gel action (as plasma arches, halogen curing lights, light emitting diodes (LED), LED plus lasers, lasers). It is believed that light source possesses the capability of stimulating the HP.[9] In chemical bleaching the same as light activated products, HP is the most effective ingredient; it is a steady complex which decomposes in water contact to release free radicals.[10] Recently, a hasten method of in-office bleaching has been launched, varying in the concentration and delivery method of HP. The chemical activated two layer technique is claimed to be highly affordable to a wide range of patient.

According to the mentioned above, the comparison of different bleaching techniques allow clinicians to take decisions with informed evidence-based, and foresee the prognosis of the treatment. The indexed literature has shown that there are few studies which evaluated and compared the enamel color change and surface roughness. Hence, a comparative study between the three techniques was performed and hypothesized that there would be no statistical differences between them either in enamel color change or in surface roughness.

MATERIALS AND METHODS

Three in-office teeth bleaching materials which are commercially available; one light-activated bleaching agent (Zoom) and two chemical-activated agents (Dash, Quick pro) were used in this study. The full description of these materials is described in Table 1.

METHODS

Sample Size Calculation

Sample size calculation was according to previous research.[11] The G power program version 3.1.9.7 was used for sample size calculation according to affected size of 1.7 with α error =0.05, 2-tailed test, and power =85.0%. The sample total size was 7 in each group at least.

Teeth Selection

Seventy human permanent incisors were extracted from healthy individuals because of periodontal disorders. They were taken from Mansoura University Faculty of Dentistry's Oral Surgery Department's Outpatient Clinic. The selected teeth were visually evaluated then with stereomicroscope (SZ TP, Olympus, Tokyo, Japan) to ensure the absence of any defects, caries, or

TABLE (1) The full description of the materials used in the study

Materials	Description	Composition	Manufacture	Lot Number
Philips ZOOM! In-office bleaching system	Light - activated tooth bleaching agent.	25% Hydrogen peroxide, Potassium hydroxide Water, Eugenol, Poloxomer 407, Mentha Piperita, Propylene Glycol, Ferrous Gluconate, Potassium Nitrate, Glycerin.	Discus, Dental, LLC Ontario, CA, USA	19303025
Philips Dash in-office bleaching system	Chemically activated tooth bleaching agent.	30% Hydrogen Peroxide , hydroxyethyl, Water, Glycerin, Etidronic acid, Acrylate/ Sodium Acryloyldimethyl taurate copolymer, Ammonium hydroxide, Potassium stannate.	Discus, Dental, LLC Ontario, CA, USA	6290
Zoom QuickPro take-home in-office Whitening varnish	Chemicalactivated tooth bleaching agent	20% hydrogen peroxide, Potassium nitrate, Sodium fluoride.	Ultradent Products, South Jordan, USA	16352011
Coca-Cola	Staining solution	Coca flavor, Caramel color Carbonated water, Phosphoric acid, Caffeine, High fructose corn syrup.	Coca-Cola Egypt	221155079282

cracks. Teeth were cleaned from any deposits, calculus and periodontal attached tissues utilizing an ultrasonic scaler and thoroughly washed with running water.

They were subjected to infection control standards approved from Ethical committee in Faculty of Dentistry, Mansoura University. Sixty teeth were chosen and disinfected for two days in a thymol solution 1%. Afterwards, they were kept in distilled water at 4±1̊C until being used; the water was renewed daily. [12]

Specimen Preparation

Each tooth was sectioned transversely at the cemento-enamel junction using a diamond instrument (Isomet, Buehler, USA). The root was cut. Next, each tooth was supported in cylinder plastic polyvinyl chloride (PVC) mold with a 1cm height and 2 cm width using chemical-polymerized acrylic resin (Acrostone, Egypt). Therefore, they could be carried easily without contamination during the bleaching agents' application. Each tooth was invested in the manner that only the labial surface was exposed. Afterwards, each tooth's flattening of their labial enamel surface was carried out using aluminum oxide abrasive papers of different grits (400, 600, 800, and 1000) with water coolant. Finally, a paste with rubber cup (Prophy Paste, PSP Dental Company, Kent, UK) was used for polishing. The blocks were enumerated for correction pen (water proof, china) for each group, as shown in figure (1).[13]

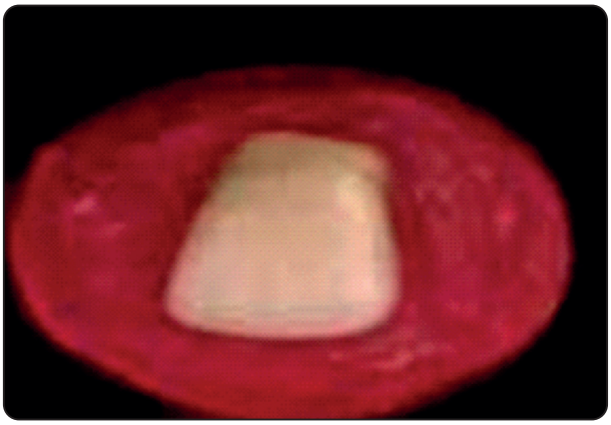

Fig. (1) Specimens preparation and mounting in acrylic resin blocks

Study Design

Sixty teeth were assigned into two main groups; enamel color change study group (n=30), and the surface roughness evaluation group (n=30). After that, each study group was further assigned into 3 subgroups based on the bleaching material utilized (n=10).

Staining Protocol

The enamel color change study group specimens were kept in cola soft drink (Coca-Cola Co., Egypt). To block the leakage of carbonic gas, the lids of the containers were tightly closed; a new bottle was utilized daily. Teeth were stored for 7 days.[14] After storage; teeth were rinsed by water and dried. Spectrophotometer was used to evaluate color (Model RM200QC, X-Rite, Neu-Isenburg, Germany). They were represented as stained group.[15]

The bleaching gel application groups

• ***Zoom (Light-activated bleaching agent)***

On the labial surface of each tooth, Zoom gel was applied according to manufacture¢s instructions in a 1-2 mm layer thickness. The thickness was determined by a clear template with a premeasured reservoir. Philips Zoom speed light device was used for gel activation (ZOOM! White speed Power Pack, Whitening LED Accelerator, 350-400 WL violet coloration, 195mW/cm^2 intensity of light, Philips). It was activated for 15 minutes to each tooth. These procedure was repeated for (2 cycles, 15 minutes each) resulting in 45 minutes as a full bleaching time. After each session, the bleaching gel was removed using suction tip. After last session, it was rinsed with air/water syringe. Finally each tooth was dried with gauze

• ***Dash (Chemical-activated bleaching agent)***

On each tooth labial surface, gel application was done using a supplied swab. It was applied following the manufacture¢s instructions as a 1-2 mm layer thickness. The thickness was determined by a clear template with a pre-measured reservoir. It was left for (15 minutes, 3 sessions) on each tooth. Then, the material was removed after each session using suction tip. Then after last session, it was rinsed by air/water syringe. Finally each tooth was dried with gauze.

• ***Zoom Quick Pro (two layer application technique)***

Zoom quick pro whitening varnish was applied directly onto each tooth labial surface; with a 1-2 mm layer thickness. The thickness was determined bb a clear template with a premeasured reservoir. It was left to dry for 30 seconds. Hereafter, it was covered by sealant layer that dried for 30 seconds. Bleaching gel was remained for 30 minutes on the teeth. After that, it was removed using suction tip. After last session the bleaching gel was rinsed with air/water syringe. Finally each tooth was dried with gauze.

Color Measurements

Specimens color was evaluated with a reflective spectrophotometer in accordance with the Commission International de 1'Eclairage L*a*b* system CIELab.[16] The CIE-Lab is represented with the L* coordinate that represent the color luminosity (white - black). In addition to the a* and b* coordinates which represent the chromaticity of color with axes that range from green to red and blue to yellow respectively. The aperture size of spectrophotometer was maintained at 4 mm. The color measurement was assessed at three time intervals at baseline then after staining procedures and finally after the bleaching agents application. Three measurements were recorded for each tooth then their averages were determined.

Enamel Color Change

The change of enamel color was assigned by the color differences among CIE L* a* b* coordinates

(ΔE^*) at baseline, after staining then after exposure to the bleaching agents. Color change mean value (ΔE) was measured for each group. The enamel color differences would be determined by the comparison of the differences among the color coordinate parameters at baseline (0) and following each treatment (1) as shown: $\Delta a = a1 - a0$, $\Delta b = b1 - b0$ and $\Delta L = L1 - L0$. Finally, the color differences (ΔE) were measured following the formulation:

$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$.[16]

Surface Roughness Evaluation

A non-contact optical profilometer was used to evaluate the surface roughness at baseline and after bleaching. For each tooth, the middle third of the facial enamel surface was assessed three times, and the average was then determined. Consequently these outcomes were used for comparing the roughness of enamel surface before and after the bleaching application.[17] Specimens were evaluated under a digital microscope. It was linked to an IBM-compatible computer via an integrated camera. Its magnification remained constant at 120X. A resolution of 1280 × 1024 pixels was utilized for images evaluation. After that, a three dimensional (3D) picture was done for the specimens surface profile. Images were evaluated for each specimen at area of 20 μm × 20 μm; the central area and the sides. Finally, WSxM software was utilized for calculation of surface roughness average (Ra).[18]

Statistical Analysis

Data were analyzed using SPSS (statistical package for social sciences). The level of significance was adjusted at $p \leq 0.005$

RESULTS

The data was tabulated and analyzed statistically by the statistical package for social science (SPSS) computer program version 26.0. ShapiroWilk test was utilized for the evaluation of the data normality. It found that data was within the normal distribution curve. The data analysis was based on one-way analysis of variance (ANOVA) followed by post-hoc Tukey test. Additionally, Student's t-test(paired) was utilized to compare the mean value of data between two groups,.

Enamel Color Change Results

No statistical significant difference was assessed within any of the tested groups, according to the one-way ANOVA findings (P=0.2381). Furthermore, a significant difference was found in the mean of all tested groups (P=0.0111). The Zoom group was recorded the highest mean value (31.4±5.3), Dash group (25.8±9.4) quick pro group the least (24.7±6.4) (Table 2, Figure 2). In enamel color change (ΔE), a significant difference was revealed among the Zoom and the Dash groups (P1=0.014) according to post-hoc Tukey test. Additionally, there was significant difference (P2=0.047) among the Zoom and quick pro groups. Nevertheless among the Dash group and the quick pro group, there was no significant difference (P3=0.889) as shown in Table 2, Figure 2.

Enamel Surface Roughness Results

Before bleaching, the outcomes of the one–way ANOVA test for all tested groups showed no statistical significant difference (Zoom, Dash, quick pro) (P=0.37). Additionally after bleaching, no statistical significant difference was found among of all tested groups (Zoom, Dash, quick pro) (P=0.75) as shown in Table 3, Figure 3, 4.

According to Pearson's correlation test, no significant correlation was exhibited among the color change and surface roughness of enamel (Table 4).

TABLE (2) Mean and standard deviation of enamel color change ΔE, ΔL before and after bleaching for all studied groups

		Study groups						p- VALUE
		Zoom		Dash		Quick pro		
Before bleaching	Mean±SD	ΔE 34.5±6.5	ΔL -21.62±11.3	ΔE 33.01±12.1	ΔL -19.86±9.2	ΔE 30.1±7.2	ΔL -20.12±10.6	0.237
After bleaching	Mean±SD	ΔE 31.4±5.5	ΔL 13.09±2.7	ΔE 25.7±9.4	ΔL 11.4±8.8	ΔE 24.7±6.2	ΔL 14.10±3.1	0.012
	Post-hoc	P1=0.015*		P2=0.046*		P3=0.887		

*: significance if p< 0.05 , P: Probability P1 : comparison between Zoom & Dash group
P2 : comparison between Zoom & Quickpro group P3 : comparison between Dash & Quick pro group

TABLE (3) Mean and standard deviation of enamel surface roughness for all groups before and after bleaching

		Zoom group	Dash group	Quick pro group	p value
Before bleaching	Mean±SD	2.55±.04	2.51±.11	2.53±.12	0.39
After bleaching	Mean±SD	2.56±.04	2.57±.03	2.56±.02	0.75

TABLE (4) Pearson's Correlation test results before and after bleaching for all study groups among enamel color change (ΔE) and surface roughness

Enamel Color Change (ΔE) vs Surface Roughness			
		Before bleaching	**After bleaching**
Zoom	r	.3851	.2251
	P	.0841	.3271
Dash	r	.1481	.1321
	P	.5231	.5691
Quick pro	r	.2721	.0561
	P	.2331	.8081

r: Pearson's correlation P:Probability , Significance P<0.05

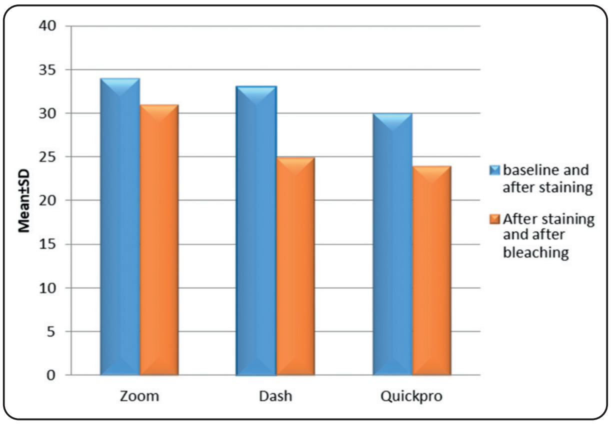

Fig. (2) Chart showing the influence of various bleaching techniques on enamel color change

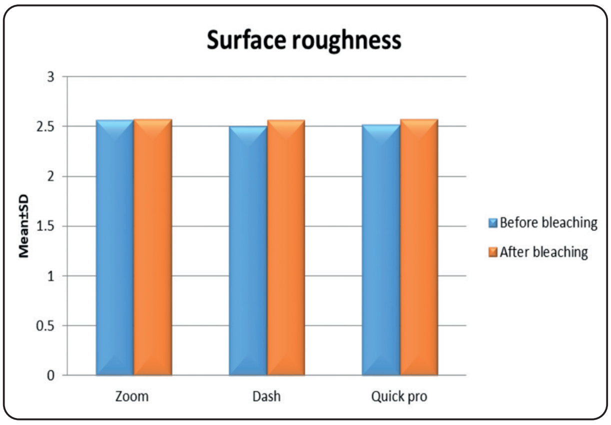

Fig. (3) Chart showing the influence of various bleaching techniques on enamel surface roughness

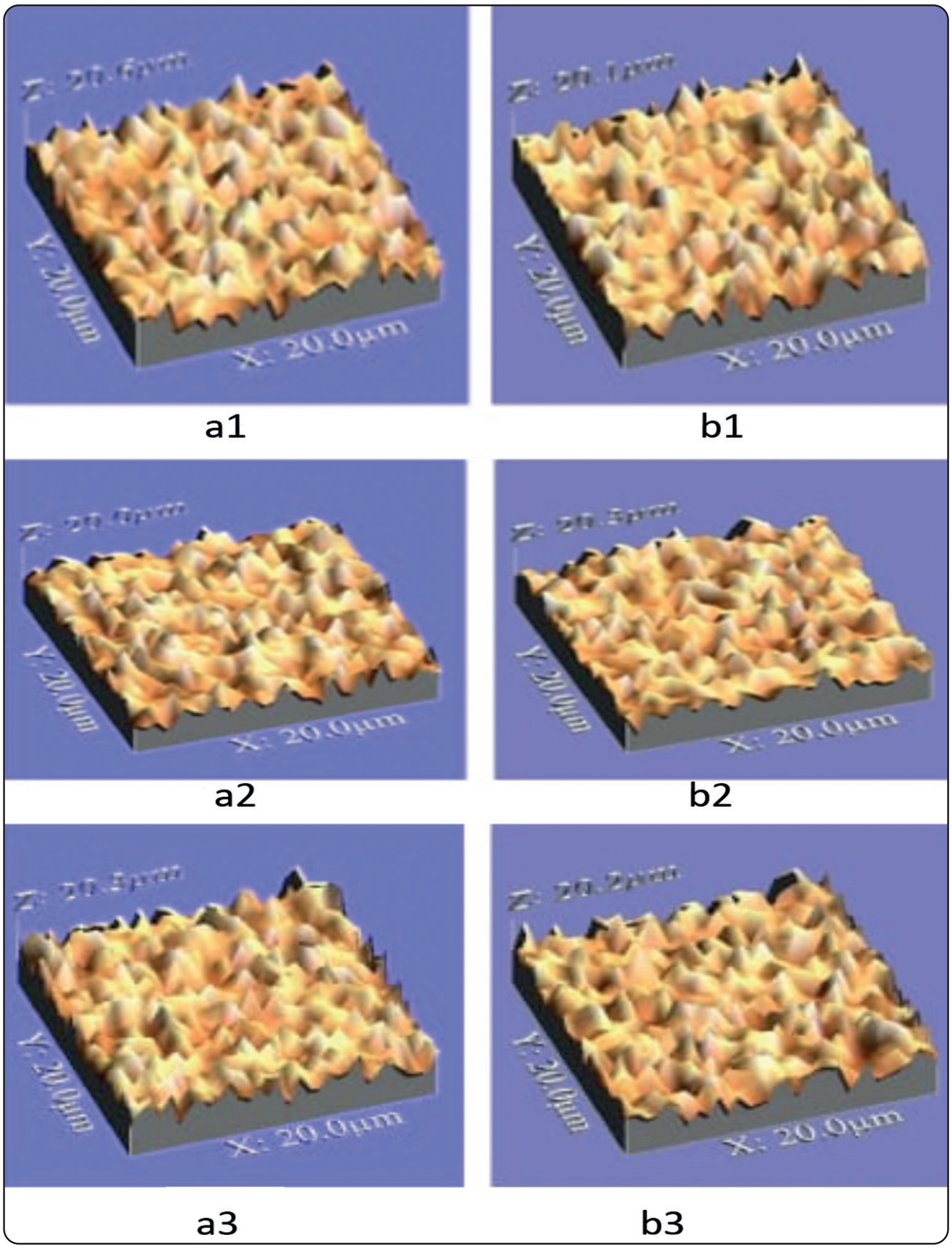

Fig. (4). Group 1 a1. unbleached enamel surface, b1. bleached enamel surface, Group 2; a2 :unbleached enamel surface, b2 bleached enamel surface, Group 3; a3 : unbleached enamel surface, b3 bleached enamel surface.

DISCUSSION

Since vital tooth bleaching treats stained teeth without the need for restoration, it is regarded as a crucial part of conservative esthetic dentistry. In-office bleaching is more common and effective than at home bleaching. Because of dentist control, less treatment time, guard against material ingestion, soft-tissue protection, more patient satisfaction, and immediate results.[19]

The materials utilized in this study with various activation modes, concentrations of HP, and application technique. The light-activated bleaching agent has a unique photo-fenton reaction. It permits the production of more hydroxyl ions with the usage of low concentration of HP. In addition, the manufacture aimed that it bleach teeth with an average of eight shades approximately.[20, 21] However, the chemically accelerated bleaching does not need any extra equipment and cause lessening for sensitivity as using a light source raises the intra-pulpal temperature which makes teeth more sensitive. It was claimed to have a superior stability and ease of use. In addition, the aim of the two layer technique is to save time and increase the efficiency. Additionally, it provides everything you need in one all-inclusive kit. [22, 23]

The teeth were stained using cola soft drink because, according to spectrophotometer data, chromogens demonstrated repeatable stain improvement. The sulfite ammonia caramel content of cola soft drink is responsible for its increased chromogenic effect.[24] Because they provide accurate and repeatable results for color measurements, Spectrophotometers are most widely used techniques for measuring color. [25, 26] The CIE L*a*b* method was utilized for color measurement; brightening occurs with the increase of the L* parameter and the decrease of redness (lower a* parameter) and yellowness (lower b* parameter). The CIE L*a*b system is usually used for objective assessment of bleaching quality and offered additional information to differentiate minor color variations.[27]

The study outcomes considering enamel color change showed that all the studied bleaching agents were led to a whitening effect for enamel. This finding is in agreement with the outcomes of Russo et al.[28] and Cvikl et al.[29] who investigated the impact of bleaching gels at varying concentrations on the enamel color change and came to the conclusion that all bleaching agents effectively whiten the enamel samples, regardless of the concentration of peroxide in them.

Moreover, the ΔL values among the tested bleaching agents were increased after bleaching despite of the differences in chemical composition, HP concentration and mode of activation. These results were in accordance with Kolsuz et al,[30] who evaluated three bleaching agents with different composition and HP concentration and concluded that after the bleaching application, all three bleaching agent increased L* values which indicated that the tooth become lighter and its brightness increased.

Additionally, the two chemically-activated groups' mean ΔE values differed significantly from the light-activated groups. The groups with chemical activation yielded lower mean values than the light-activated bleaching technique. This outcome can be explained by using a light source and HP resulting together to activate the latter, speed up the chemical redox reaction during the bleaching process, also increase the bleaching agent's whitening efficacy.[31]

These outcomes were in agreement with the findings of Park et al.[32] and Lilaj et al.[33], who assessed the efficacy of chemically and light-activated in-office bleaching materials. They discovered that the light-activated technique offered the highest efficiency bleaching. Additionally, they surmised that the efficacy was dependent on the fenton reaction.

The present study result's contradicts to Almedia et al.[34] who concluded that light source could not improve in-office whitening outcomes. This discrepancy might result from their attempt to use a light source to enhance chemically activated bleaching agents, despite the agents' lack of indication that they needed light to activate. Furthermore, two chemically-activated bleaching agents did not significantly differ from one another, according to the results of the enamel color change.

These outcomes were agreed with Sa et al. [35], who suggested using bleaching agents with lower concentrations and found no significant difference in the effect of varying hydrogen peroxide concentrations on the final color after bleaching.

Furthermore, this outcome is consistent with that of Bacaksiz et al.[36], who revealed no discernible variation in color change across various peroxide concentrations

One of the most obvious issues following tooth-bleaching procedures is the roughness of the enamel surface. To prevent surface damage from wear or indentation, the non-contact profilometer was utilized to assess the enamel's surface roughness. According to the outcomes of surface roughness, all examined groups' did not differ significantly before and after bleaching. These results supported the conclusions of de Carvalho et al.[37]and Altınışık H et al.[38] who exhibited no significant raise in surface roughness following the bleaching protocol.

The current study's findings, nevertheless, are contrary to those of Abouassi et al.[13] and Anaraki et al.[39], who assessed the impact of various bleaching methods on the surface roughness of enamel and discovered that both methods might raise it. The use of a different light source (a diode laser), the concentration of HP bleaching chemicals, and the timing of application could be the cause of this disagreement. Therefore, the null hypothesis that there would be no differences among different bleaching techniques either in enamel color change or in surface roughness was rejected.

CONCLUSIONS

Within the study's limitation, it is possible to conclude the following:

1. All the studied in-office bleaching approaches were effectively whitening the teeth.
2. Compared to chemically activated bleaching, light activated bleaching systems produce a more noticeable whiter smile.
3. All studied bleaching systems did not reveal enamel roughness.
4. No correlation was detected among enamel color change and surface roughness.

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