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COMPARATIVE EVALUATION OF TWO BLEACHING SYSTEMS ON TEETH SHADES AND THEIR SURFACE ROUGHNESS, ONE YEAR FOLLOW UP

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ABSTRACT

Aim: This study was carried out to compare the ability of two in-office bleaching systems (Philips Zoom White and Fläsh White Smile) to lighten teeth immediately, after one week, and after one year. In addition, the surface roughness of enamel was evaluated before and just after bleaching. **Materials and Method:** Forty healthy human participants were selected. Three applications of the bleaching gel of 15 minutes each were and the whole session duration was 45 minutes. The teeth shade was recorded using a digital camera and a contact-type intraoral spectrophotometer. Addition silicone-based impression material was used to record the upper anterior teeth's surface topography just before and after the bleaching session. Epoxy resin cast was gold-sputtered to be examined under vacuum using a field emission scanning electron microscope attached to EDX unit. Images were taken in representative areas at 500X magnification. **Results:** ΔL, ΔA, and ΔB showed no statistically significant difference between the ZOOM and Fläsh at the three-time intervals. In the Fläsh group, ΔE 1976 and ΔE 2000 increased significantly after one week. Fläsh showed a statistically significantly higher Δ H after one year and higher ΔC immediately after, after one week, and after one year. The intragroup comparison showed no statistically significant difference between the different time intervals for all variables in the Zoom and Fläsh groups. **Conclusion:** Both bleaching systems are effective in-office bleaching systems and showed long-term effects up to one year. The surface roughness of enamel was not altered following bleaching with either technique.

KEYWORDS: Bleaching shade, spectrophotometer, field emission scanning electron microscope, EDX, resin replica

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INTRODUCTION

Teeth bleaching is considered one of the most atraumatic treatment modalities for discolored teeth[1]. The mechanism of hydrogen peroxide bleaching is explained by a number of theories the most accepted one is that oxygen free radical diffuses through the enamel and then dentin and interacts with the organic chromophores discoloring teeth.[2] In-office bleaching utilizing 20–38% hydrogen peroxide (HP), dentist-supervised home bleaching with (5-35 %) and/or over-the-counter bleaching agents are different techniques of bleaching.[3] In comparison to other bleaching techniques, in-office bleaching offers a number of benefits.[4] Numerous studies showed that the decomposition of hydrogen peroxide is influenced by peroxide concentration and exposure to direct light and/or heat.[5] Power sources such as tungsten halogen, plasma arc, light emitting diode (LED), LASERs, and LED plus LASER can be used to speed up the action of the bleaching gel.[6]

Assessments of teeth staining and bleaching effects can be made using subjective comparison methods or objective instrumental methods. The visual assessment of shade by comparing a patient's tooth with a commercially available shade guide is very subjective although it is the most frequently applied technique in clinical dentistry. Discoloration and shade change can be objectively assessed via a variety of approaches. Examples of these approaches are; colorimetry, spectrophotometry, and computer analysis of digital image.[7] They measure an object's reflectance by a single wavelength at a time and are based on the (CIELAB) system, which was defined by the International Commission on Illumination in 1967.

Few studies assessed the bleaching's effect on enamel in vivo. Most studies depend on subjective morphologic evaluation of the enamel surface, rather than precise measurements of the enamel surface profile.[8] That is why it is important to analyze the enamel surface profile following in-vivo bleaching. This study was performed to examine the capabilities of two power bleaching systems; Philips Zoom White Speed (25% Hydrogen Peroxide) and Fläsh White Smile (32% Hydrogen Peroxide) to lighten teeth immediately, after one week and after one year. In addition, the surface roughness of enamel was evaluated before and just after bleaching.

MATERIALS AND METHODS

A- Participant Selection

This study was approved by the Faculty of Dentistry MSA University ethical committee number ETH 28. Forty healthy human volunteers (20-30 years old) were chosen from the MSA University Faculty of Dentistry's outpatient clinic. They were divided into two equal groups according to the bleaching system used. All chosen participants had their six anterior teeth darker than A2 shade. They should have good oral hygiene, willingness to be included in the study, and the ability to follow up during the study. Participants who have any of the following were excluded from the study; anterior restoration, non-carious lesion, non-vital teeth, gingival recession, periodontal disease, non-functional habits, bruxism, painful symptoms, tooth sensitivity, fluorosis, tetracycline staining, smoking, previous bleaching, orthodontic treatment, systemic illness, pregnancy or nursing. Participants signed an informed consent form after understanding the bleaching process and any potential adverse effects. One week before the bleaching procedure, the participants had their teeth professionally cleaned, polished and were told to brush their teeth twice a day to eliminate gingival inflammation.

B- Randomization and Concealment:

Two light-activated in office bleaching systems were selected in this study. The bleaching system's composition, the gingival protector, the desensitizing agent and the light activation lamp type are shown in Table (1).

TABLE (1) The composition of the bleaching system, the gingival protector, the desensitizing agent, and the activation lamp type

Bleaching system	Bleaching agent composition	The activation lamp	Gingival protector	Desensitizing agent
Philips Zoom White Speed, Discus Dental, LLC, Los Angeles, CA 90094 USA	25% hydrogen peroxide, glycerin, eugenol, water, polyethylene, polypropylene glycol, Mentha piperita oil, eugenol, bis (D-gluconato-O_1, O_2), dihydrate. 1-hydroxyethane-1,1-diphosphonic acid, potassium nitrate, and iron.	Philips Zoom White Speed whitening, LED Accelerator. (400 to 505 nanometers)190-50 mW/cm^2), Discus Dental, LLC	Liquidam, soft tissue isolation, Discus Dental, LLC, Ontario, CA 917761 USA	Relief, amorphous calcium phosphate (ACP)
Fläsh White smile, Weinheimer Str,6, 69488 Birkenau/ Germany, Fläsh.com	Hydrogen Peroxide 32%, organic amines, chlorophyll, and silicon dioxide	Fläsh White Smile, Whitening Lamp, WHITE smile GmbH, (460nm, 190-50 mW/cm^2), Weinheimer Str,6, 69488 Birkenau/ Germany, www.whitesmile.com	Fläsh White Smile GmbH, Weinheimer Str,6, 69488 Birkenau/ Germany, Fläsh.com	Fläsh, after Whitening Mousse (30 % Xylitol, 4.2% Potassium Nitrate, 1450 ppm Sodium Fluoride, Sodium Phosphate, Calcium Nitrate, Sodium Saccharin, Natural Mentha Piperita Poloxamer 338 and Water

A third person who did not take part in the study concealed the commercial names from the activation lamp, gingival protect, bleaching agent, and desensitizing agent of each product. They were assigned sequential numbers to denote their usage sequence. In addition, each bleaching system was covered with a certain color. Colored cards were prepared to denote the type of the bleaching agent.

At the start of the bleaching session, each participant was asked to choose one of these sealed cards, which marked the type of the bleaching system that would be used for him/her, and each participant was requested to put his/her name on the selected card for simple recording. Neither the operator nor the participants were allowed to know the type of bleaching agents used. As a result, the participants were split into two equal groups according to the type of bleaching system used. Photographs were taken for the upper and lower six anterior teeth of each participant before and after each bleaching session and after each follow up.

C- Impression taking:

An addition silicone-based impression material (Elite HD$^+$, Zhermack, Italy) was used to evaluate the surface topography of the upper six anterior teeth just before and just after the bleaching session before the application of the desensitizing agent. This impression was washed with running tape water, disinfected by immersion in sodium hypochlorite 0.5% for 5 minutes[9] and then poured with epoxy resin (Coloresin Clearoxy Epoxy Resin, Egypt)

D- Participants preparation:

Single use lip Balm (Safetec, America) was applied to the lips and around the corners of each participant's mouth. Isolation was done using the tongue and cheek retractor supplied with each kit. In addition to the gingival barrier was applied on the gingival margin and labial alveolar mucosa of the upper and lower six anterior teeth and then

light activated using the light emitting diode (Elipar Deep Cure-S, 3M ESPE, St. Paul, MN, USA) for 1 second. Isolating-cotton rolls were inserted into the muco-labial fold, and a low volume suction was inserted lingually. Each participant is then reclined on the dental chair, and both the participant and the operator wore LED protective goggle (Discus Dental, LLC, USA).

E- Bleaching agents' application

Using the manufacturer's syringe, the activator and bleaching agent were auto-mixed and applied in a 1-2 mm thick layer to the labial surfaces of the anterior upper and lower teeth in both test groups. Each bleaching system included a specific light emitting diode lamp (LED) that was set to the maximum power (190 mW/cm^2) for the first 15 minutes, then to the medium power (120 mW/cm^2) for the next 15 minutes for two consecutive sessions. Each session included three applications of the bleaching gel, with a total session time of 45 minutes. Following each session, the bleaching gel was removed with high-volume suction and gauze, and freshly mixed gel was applied. The bleaching gel and gingival protector were removed after the third session, and each participant was asked to rinse his or her mouth with water. The teeth shade was recorded again and another impression was taken for the upper anterior teeth. The desensitizing agent of each kit was administered and left for ten minutes after drying and isolating the bleached teeth using cotton rolls, low volume suction, cheek and tongue retractor. The participants were then asked to refrain from eating or drinking for 30 minutes and from eating or drinking anything colored for at least two weeks. For the entire duration of the trial, they were also told to floss and clean their teeth after each meal using a non-whitening toothpaste.

F-Teeth shade recording

The teeth shade was recorded for each participant just before, just after, one week and after one year of the bleaching session using a contact-type intraoral spectrophotometer device (Vita Easy Shade, VITA Zahnfabrik H. Rauter GmbH & Co. KG). This device has a spectral range of 400 to 700 nm and a wavelength of 25 nanometer. It has a 5 mm diameter probe which was placed at the middle third of the labial surface of each tooth being examined. This device is calibrated according to the CIELAB (Commission Internationale d'Éclairage L*a*b*) and it also can measure the chroma (C*) and the hue (H*). The luminosity was indicated by the L* where black= 0 and white=100. In addition, the shade is represented by a* and b*, where a* represents the measurement along the green -red axis and b* represents the measurement along the blue- yellow axis. The records of the easy shade data of each participant were video recorded and then these data were saved in Microsoft Excel documents to be statistically analyzed. Participants who failed to maintain their follow-up appointments were dropped from the study.

G- Scanning Electron Microscope (SEM) Analysis

After complete setting of the epoxy resin cast, it was cleaned from any debris using an ultrasonic cleaner (Small Mini Digital Ultrasonic Cleaner, Uc-4055, China) and left to dry. It was then gold sputtered in a vacuum evaporator (Emitech K550X sputter coater, England) to be examined under vacuum in a Field Emission Scanning Electron Microscope (Quanta 250 FEG, Field Emission Gun) linked to an EDX unit (Energy Dispersive X-ray Analyses, Netherlands). Images were recorded in representative locations at 500X magnifications. Scandium Olympus Software Imaging incorporated in the scanning electron microscope was used to perform image analysis to quantify the surface roughness of the poured epoxy castings before and after bleaching, surface calibration and latitude measurements in three dimensions were recorded.

H- Statistical analysis

Seventeen participants from the P Zoom WS and thirteen participants from the Fläsh WS strictly attended the follow-up, while those who failed to maintain their follow-up appointments were

dropped from the study. The data was loaded into the computer and analyzed with the IBM SPSS software program version 20.0 (IBM Corporation, Armonk, New York). Range (minimum and maximum), mean, standard deviation, and median were used to express quantitative data. Because the quantitative variables were not normally distributed, the Mann Whitney test was used to compare the two groups, while the Friedman test was used to compare the three periods and the Post Hoc Test (Dunn's) for pairwise comparisons. The obtained results were determined to be significant at a 5% level.

RESULTS

A- The outcomes of the teeth shade parameters:

The mean and standard deviation values are shown in Table (2) which showed that there was no statistically significant difference between Philips Zoom White Speed (P Zoom WS) and Fläsh White smile (Fläsh WS) groups at the three-time intervals. Regarding ΔE 1976 (ΔE76) and ΔE 2000 (ΔE00), Fläsh WS group showed a statistically significantly higher value of ΔE76 after one week where (p=0.003) while in ΔE00 (p= 0.010) as shown in Figure (1). As for ΔH, the Fläsh WS group showed a statistically significantly higher ΔH after one year of bleaching where (p=0.022). As for ΔC, the Fläsh WS group had a statistically significantly higher value of ΔC immediately after, after one week and after one year of bleaching where p=0.002, < 0.001, and< 0.001, respectively. Intragroup comparison in both the P Zoom WS and Fläsh WS groups found no statistically significant difference at the different time periods (p>0.05).

TABLE (2) Comparison between P Zoom WS and Fläsh WS regarding the different teeth Shade parameters at each examined period.

Tested variables	Tested periods	Flash (n = 13)	Zoom (n = 17)	U	p
		Baseline-immediately after			
	Mean ± SD.	2.32 ± 7.09	5.18 ± 6.03	91.00	0.432
	Median (Min.-Max.)	4.14 (-9.73 – 13.91)	4.08 (-4.54 – 17.01)		
		Baseline-week			
ΔL	Mean ± SD.	5.27 ± 7.41	4.39 ± 4.06	101.00	0.711
	Median (Min- Max.)	5.23 (-10.98– 16.55)	4.94 (-3.24– 9.80)		
		Baseline-year			
	Mean ± SD.	4.17 ± 4.99	8.18 ± 7.07	71.00	0.103
	Median (Min. – Max.)	5.03 (-4.30 –10.56)	7.01 (-4.16 – 24.71)		
	Fr (p_0)	Fr = 1.846, p= 0.397	Fr = 2.235, p=0.327		
		Baseline-immediately after			
	Mean ± SD.	-0.50 ± 9.09	-1.15 ± 4.24	107.50	0.902
	Median (Min.– Max.)	-0.43 (-17.58–14.55)	0.02 (-15.91 – 4.06)		
		Baseline-week			
ΔA	Mean ± SD.	-0.92 ± 9.91	-1.75 ± 3.70	107.00	0.902
	Median (Min. – Max.)	-0.9 (-21.43– 14.78)	-0.82 (-15.71– 0.48)		
		Baseline-year			
	Mean ± SD.	1.14 ± 9.23	-3.36 ± 5.47	75.00	0.145
	Median (Min. – Max.)	-0.05(-14.08 –20.18)	-0.85 (-15.93 –4.01)		
	Fr (p_0)	Fr= 0.462, p=0.794	Fr= 2.235, p= 0.327		

ΔB		**Baseline-immediately after**			
	Mean ± SD.	-2.50 ± 3.68	-1.76 ± 4.19	94.00	0.509
	Median (Min. – Max.)	-2.52 (-8.12 – 5.58)	-1.25 (-10.07– 4.51)		
		Baseline-week			
	Mean ± SD.	-2.86 ± 4.0	-3.47 ± 3.76	91.00	0.432
	Median (Min. – Max.)	-1.87 (-10.37– 4.05)	-4.78 (-8.30– 6.64)		
		Baseline-year			
	Mean ± SD.	-3.96 ± 3.74	-3.75 ± 2.78	104.00	0.805
	Median (Min. – Max.)	-4.40 (-10.37– 2.11)	-3.98 (-7.60– 1.20)		
	Fr (p_0)	Fr = 0.510, p=0.775	Fr= 1.412, p= 0.494		
ΔE1976		**Baseline-immediately after**			
	Mean ± SD.	11.05 ± 5.21	8.48 ± 5.35	81.00	0.229
	Median (Min. – Max.)	9.51 (3.51 – 19.21)	8.30 (1.84 – 17.62)		
		Baseline-week			
	Mean ± SD.	12.92 ± 5.33	7.98 ± 3.62	42.00*	0.003*
	Median (Min. – Max.)	11.83 (3.76 – 22.56)	7.23 (4.09 – 19.45)		
		Baseline-year			
	Mean ± SD.	11.16 ± 5.14	11.74 ± 6.25	104.00	0.805
	Median (Min. – Max.)	11.04 (2.49 – 21.10)	9.34 (4.57 – 24.74)		
	Fr (p_0)	Fr = 0.615, p = 0.735	Fr = 3.176, p = 0.204		
ΔE2000		**Baseline-immediately after**			
	Mean ± SD.	8.58 ± 4.72	6.37± 4.68	75.00	0.145
	Median (Min. – Max.)	6.24 (2.13 –16.21)	5.0 (1.19 –18.37)		
		Baseline-week			
	Mean ± SD.	9.73 ± 4.88	5.69 ± 3.88	50.00*	0.010*
	Median (Min. – Max.)	8.66 (2.52 – 18.63)	4.65 (2.36 – 19.42)		
		Baseline-year			
	Mean ± SD.	8.51 ± 5.28	8.68 ± 5.25	110.00	1.000
	Median (Min. – Max.)	7.30 (1.90 –20.96)	6.28 (2.47 –17.31)		
	Fr (p_0)	Fr= 1.385, p= 0.500	Fr= 2.471, p= 0.291		
ΔH		**Baseline-immediately after**			
	Mean ± SD.	0.70 ± 10.15	-0.69 ± 4.59	101.00	0.711
	Median (Min. – Max.)	-0.52 (-16.45–18.96)	0.01 (-16.20 – 7.23)		
		Baseline-week			
	Mean ± SD.	-2.20 ± 8.97	-2.18 ± 3.93	100.0	0.680
	Median (Min. – Max.)	-1.21 (-21.59 –13.18)	-1.35 (-17.06 – 0.62)		
		Baseline-year			
	Mean ± SD.	6.22 ± 15.77	-2.99 ± 5.66	56.00*	0.022*
	Median (Min. –Max.)	1.47 (-14.66 –50.84)	-1.24 (-14.21– 7.38)		
	Fr (p_0)	Fr = 1.846, p= 0.397	Fr= 4.353, p= 0.13		
ΔC		**Baseline-immediately after**			
	Mean ± SD.	3.35 ± 4.85	-1.32 ± 3.65	40.00*	0.002*
	Median (Min. –Max.)	2.75 (-8.33 –12.52)	-1.26 (-8.10 –4.47)		
		Baseline-week			
	Mean ± SD.	3.15 ± 4.60	-4.65 ± 2.14	15.00*	<0.001*
	Median (Min. –Max.)	1.70 (-5.83 –10.42)	-4.72 (-8.17 –0.06)		
		Baseline-year			
	Mean ± SD.	5.25 ± 4.17	-3.17 ± 3.64	11.00*	<0.001*
	Median (Min. – Max.)	4.80 (-1.49– 10.92)	-4.18 (-7.29– 7.30)		
	Fr (p_0)	Fr= 2.923, p= 0.232	Fr= 5.940, p= 0.051		

***SD*= Standard Deviation** **U= Mann Whitney Test** **Fr= Friedman Test**

P= p value for comparing the groups under study

p_0= p value for each group when comparing three examined periods

****= Statistically significant at p ≤ 0.05***

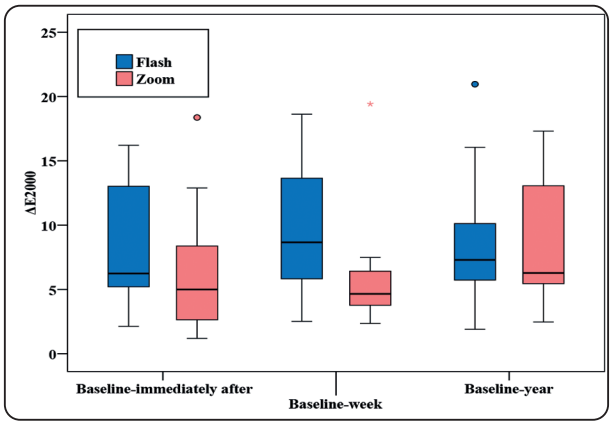

Fig. (1) Evaluation between the two analyzed groups based on changes in ΔE2000 at each examined period

B- Surface roughness:

Mean and standard deviation values of surface roughness (Ra) of the two bleaching systems were presented in Table (3) and Figure (2). Before and after bleaching, there was a non-statistically significant higher surface roughness values in the P ZOOM WS bleaching group in comparisons to the Fläsh WS bleaching group where p=0.056 and p=0.264 respectively. In the Fläsh WS group, there was a non-statistically significant increase in surface roughness after bleaching (p=0.596), but P ZOOM WS showed a non-statistically significant decrease (p=0.319).

C- Scanning Electron Microscopy Analysis (SEM)

SEM images of the bleached anterior teeth before and after bleaching in Figures (3 a, b) and (4 a, b) of P ZOOM WS and Fläsh WS bleaching systems respectively. Representative photomicrographs of unbleached specimens revealed no significant morphological alterations where the surface was smooth and uniform. After using P ZOOM WS and Fläsh WS bleaching systems, the SEM photomicrographs showed some morphological change as slight irregular surface with minute depressions and porosities of different sizes in addition to little areas of erosion that might indicate demineralization as seen in Figures (4 a, b).

TABLE (3) Mean ± standard deviation (SD) of surface roughness of the two bleaching systems

Bleaching	Bleaching technique (mean±SD)		p-value
	Fläsh WS	P ZOOM WS	
Before	3.26±0.07	5.41±1.39	**0.056ns**
After	3.52±0.71	4.26±0.68	**0.264ns**
p-value	**0.596ns**	**0.319ns**	

; significant (p ≤ 0.05) ns; non-significant (p>0.05)

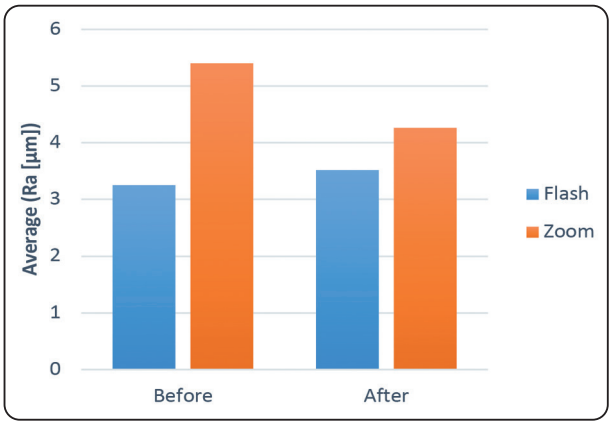

Fig. (2) Bar chart showing the average surface roughness of the two bleaching systems

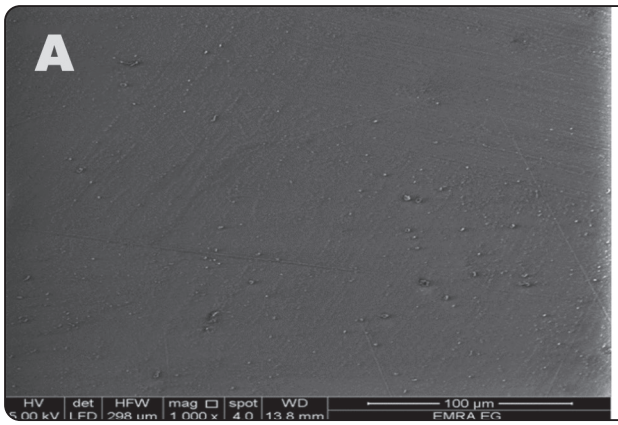

Fig. (3): A) Non- bleached enamel surface in P ZOOM WS bleaching group.

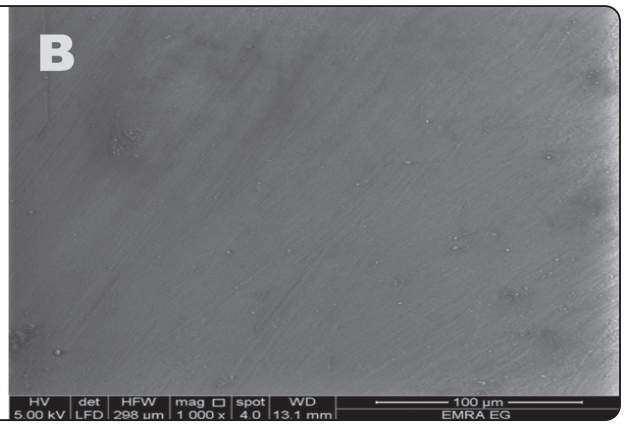

Fig (3): B) Non- bleached enamel surface in Fläsh WS bleaching group

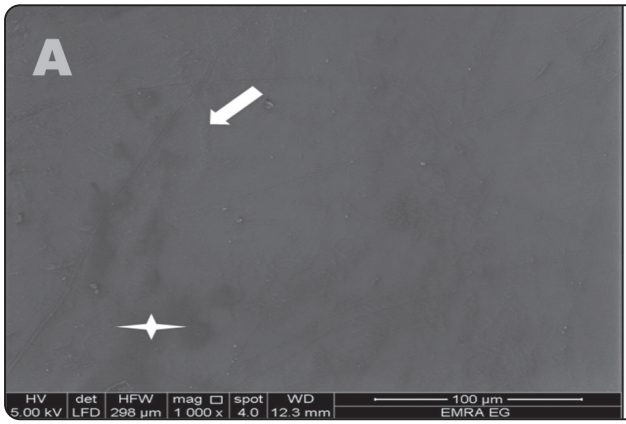

Fig. (4): A) Bleached enamel surface in P ZOOM WS bleaching group.

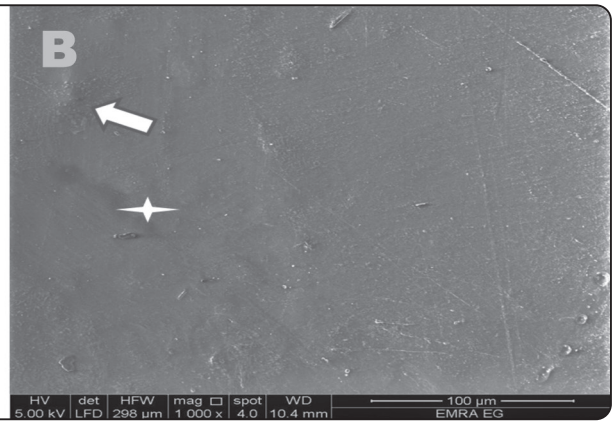

Fig. (4): B) Bleached enamel surface in Fläsh WS bleaching group.

Arrows show areas of irregularities and asterisks show areas of erosion

DISCUSSION

The most popular bleaching method is in-office bleaching because it avoids soft tissue trauma, gel ingestion, saves time, and produces a more satisfying lightening result for the participant.[10] In-office bleaching, usually utilizes different light activating sources, in order to activate the bleaching agent and to obtain a quick and effective whitening procedure. Light sources heat the hydrogen peroxide (HP), increasing its disintegration into free radicals so that it can deeply penetrate the enamel and dentin. This is known as oxy-reduction, and it occurs when the long carbon chains in (HP) are broken down into smaller ones, resulting in lighter-colored teeth.[11]

In the current research, a pair of different light activated bleaching systems were used, both of which utilized LED whitening lamps. The first is the Philips Zoom White Speed, which has produced effective results for many years, and the second one is the Fläsh White Smile, a more recent model. After using both systems for bleaching the participant's teeth, the degree of teeth shade change and the surface roughness were compared. Both subjective and objective methods; were used in this study

using the digital camera and the spectrophotometer respectively, to evaluate the teeth shade and the efficacy of the two examined bleaching systems. The spectrophotometer method was used in this study because it is easier, more accurate and gives digital results when compared to the visual method, which is less accurate and is affected by many variables as daylight, participant position, age and baseline tooth shade.[12] The values of ΔE were used to determine shade difference. The degree of variance was calculated by taking the arithmetic mean of the L* a* b* values.[11,13]

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

L* is a scale that expresses the degree of lightness or darkness and ranges from 0 (black) to 100 (white). The measurement of the red-green axis is a*. A positive a* value represents the red direction, while a negative a* value represents the green path. The yellowness-blueness axis is represented by the b* value. A shade in the yellow direction is indicated by a positive b* value, while a shade in the blue direction is indicated by a negative b* value. The shade turns neutral as the values of a* and b* get close to zero.[14] After bleaching, the teeth became lighter, as indicated by a positive difference in lightness (L*) in both systems; additionally, the negative values of (a*) and (b*) represent a shift in the green and blue directions, respectively. The Delta E 2000 (ΔE00) formula is said to be the most reliable formula for assessing shade differences because it produces results that are more in line with how shades are perceived by the human eye. The thresholds for perceptibility and acceptability are when E00 is between 0.8 and 1.8 respectively, where acceptability having a larger clinical importance.[15] As stated by the American Dental Association (ADA) Acceptance Program Guidelines, the value of color changes for professional in-office tooth whitening solutions should be ≥5 color change units (ccu) to show efficacy of the bleaching treatment; where 1 ccu= 1 shade guide unit (sgu)= 1 ΔE_{ab}.[16] In this study both Fläsh WS (ΔE76= 11.05) and P Zoom WS (ΔE76=8.48) from base line- immediately after bleaching were exceeding 5ccu, which is in accordance with the ADA guidelines, and indicates that bleaching causes very obvious changes in shade after using both systems.[17]

Additionally, the nature of the changes was also consistent with ADA literature and guidelines[16], where there is an increase in lightening and decrease in yellow chroma indicating that there was an increase in whiteness even though no statistically significant differences existed between the two examined groups. This suggests that both studied bleaching methods were able to break down the organic pigment found on the tooth tissue by the peroxide molecules, converting them into smaller molecules, diminishing the saturation of yellow chroma and presenting a whitening effect.[18]

Fläsh WS showed a significant increase in (ΔE76= 12.92) and (ΔE00= 9.73) when compared to Philips P ZOOM WS (ΔE76= 7.98) (ΔE00= 5.69) after 1 week of treatment, this might have been caused by the higher percentage of H_2O_2. in Fläsh WS (32 %) when compared to P ZOOM WS (25%).

Eugenol, ferrous gluconate, potassium nitrate, and 25% H_2O_2 are all ingredients in the P ZOOM WS bleaching gel. P ZOOM WS's bleaching procedure is based on the so-called photo-fenton chemistry, which utilizes ferrous gluconate (H_2O_2 and Fe^{3+}). When ferrous gluconate is exposed to light Fe^{3+} is transformed into Fe^{2+} and hydroxyl radical: $Fe^{3+} + H_2O_2$+ visible light $\rightarrow Fe^{2+}+ OH^- + H^+$. Many different organic substances have been shown to be severely oxidized when hydroxyl radicals are released. The benefit of this reaction is that it produces more hydroxyl ions while only utilizing a small amount of hydrogen peroxide.[4]

Fläsh WS bleaching gel, has silicon dioxide, organic amines, chlorophyll, and 32% H_2O_2. These organic amines in Fläsh WS are thought to act as a template for the precipitation of calcium and

phosphate ions found in saliva, the tooth structure and the desensitizing mousse of the bleaching agent. These minerals may promote tooth structural remineralization improving its shade.[19]

The Fläsh WS system's desensitizing agent also has 1450 ppm fluoride and potassium nitrate that reacts with hydroxyapatite crystals to generate fluorapatite and calcium fluoride.[4] It also includes chlorophyll, which has antioxidant and antibacterial effects[20] that might affect the accumulation of dental plaque on the tooth surface and accordingly decrease the number of chromogenic bacteria. The increased level of whitening seen in teeth bleached with Fläsh WS compared to P ZOOM WS may be explained by the forementioned factors.

Equally significant to the aesthetic outcomes attained right away are the bleached teeth's capacity to maintain their shade over time. Regardless of the hydrogen peroxide concentration, shade recovery may be seen following bleaching treatment. As noted by some reports, a 10% shade comeback may happen in the first year after bleaching, and it might get worse over time.[14] The P ZOOM WS and Fläsh WS intragroup comparison of ΔE00 and ΔE76 revealed no appreciable differences in their values at the various time intervals, indicating long-term stability of the bleaching effect in both systems.

Several studies have demonstrated that hydrogen peroxide whitens tooth structure, but results in morphological changes to the enamel surface in the form of increased porosity, depression, and surface imperfections leading to the increase in surface roughness. They explained the reason for that by the free radicals produced from the oxidation of H_2O_2 that acts on both organic and inorganic matrix causing a decrease in the amount of hydroxyapatite and proteins leading to adverse effects to the enamel surface even after a single application.[21,22, 23,24, 25] These adverse effects depend on the composition of the bleaching gels, the concentration of the peroxide, pH, bleaching technique protocols, and the application time.[26] Surface roughness has been measured using atomic force microscopy, scanning electron microscopy, contact stylus tracing profilometry, and non-contact profilometry. In the current study, surface roughness was assessed both qualitatively and quantitatively utilizing a polyester replica of the anterior teeth analyzed by Emission Scanning Electron Microscope (ESEM) and image analysis. This method is said to be the most significant and popular.[27]

The results of the current study showed that in-office bleaching performed with P ZOOM WS (25% hydrogen peroxide) or Fläsh WS (32% hydrogen peroxide), with the repeated application up to three treatments in a single visit, did not produce significant alterations on enamel surface roughness. The results may be explained by the bleaching agent's shorter contact time on the tooth surface (3 sessions of 15 minutes each= 45 minutes). De Carvalho et al.,[28] studied the influence of time on the surface hardness of enamel after bleaching and found that the shorter the contact time of the bleaching agent, the less the enamel hardness loss and the insignificant is the loss in surface roughness. The pH of the bleaching agents under investigation influences the surface roughness. The tested bleaching agents (P ZOOM WS and Fläsh WS) have pH values of 7- 9 and 8- 9.7, respectively. As stated by Wujetunga et al.,[29] bleaching products with a pH value of more than 6.0 can prevent the dissolution of the tooth enamel, since the critical pH value for the dissolution of the tooth enamel is (pH 5.5- 6.5). Similarly, in the current study, the bleaching agents produced minor changes in the surface roughness when compared to the baseline before the bleaching session as shown in Figures (3 and 4). However, these were not the same results as Trentino et al., 2015[30] who found an increase in the enamel surface roughness after evaluating the influence of different bleaching protocols. The difference could be related to the longer duration and the repeated sessions of bleaching compared to the current study. It worth mentioning that, there was an insignificant rise in surface roughness in the Fläsh WS after bleaching while there

was an insignificant reduction in the P ZOOM WS. This might be because the Fläsh WS has a higher concentration of 32% (HP) than the P ZOOM WS system (25%), which will allow for deeper penetration which agrees with several studies.[26]

CONCLUSIONS

1- Both bleaching systems Philips Zoom White Speed and Fläsh White Smile are effective in office bleaching systems.

2- Fläsh White Smile has more effective bleaching effect when compared to Philips Zoom White Speed.

3- Both systems show long term stability of the bleaching effect up to 1 year.

4- The surface morphology of the enamel surface was not significantly altered following bleaching with either technique.

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