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Comparing The Effect Of Er,Cr:YSGG Laser And Sodium Fluoride On The Color Change Of Artificial White Spot Lesions In Primary Teeth

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ABSTRACT
Background: *Caries teeth are a well-recognized source of pain and discomfort, and when it strikes, toothache is distressing for the child and is disruptive for other family members. Therefore, the prevention of caries in children and adolescents is considered as a priority and cost-effective than its treatment.*
Objective: *The purpose of this study is to compare the effect of using Er,Cr:YSGG laser, and Sodium Fluoride gel 2% on the color change of the white spot lesions of the primary teeth.*
Materials and Methods: *A total of thirty-nine freshly extracted, primary anterior were used in this study and were divided into three groups, thirteen specimens in each group according to the type of treatment used. The root portion of each tooth was cut at 1 mm below the cementoenamel junction, and each crown was bisected by a diamond disk in a mesiodistal direction and mounted on acrostone acrylic resin. The whole block was painted with a double layer of nail varnish and leaf 4*4 mm square window was placed on the labial surface.*
Results: *All specimens were stored in artificial saliva, and after 24 hours color was evaluated (remineralization stage, T2). All the specimens were restored in artificial saliva that was changed every 48 hours. After the 30-day interval, color measurement was carried out, and L, a, and b values were recorded again (final measurement, T3). The results of the present study showed a significant improvement in the color of white spot lesions in all groups treated. The highest value was found in the fluoride & laser group (3.88±0.18), followed by the fluoride group (2.79±0.18) while the lowest value was found with laser group (1.89±0.13).*
Conclusion: *Based on the results this study, it can be concluded that: The irradiation of WSLs with Er, Cr:YSGG laser through the NaF gel was more effective in improving the appearance of white spot lesions. Fluoride alone is less effective in improving the appearance than combined laser an fluoride. Er, Cr:YSGG laser alone was the lowest effective in restoring the appearance of white spot lesions.*
Keywords: *Er,Cr:YSGG Laser,*

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I. INTRODUCTION

Dental caries is still a major public health issue in most nations, yet it is one of the most frequent and preventable pediatric illnesses**(1)**. Initial carious lesions, often known as "white spot" lesions are usually reversible and they represent a subsurface area with the majority of the mineral loss beneath a relatively undamaged enamel surface**(1, 2)**.

For remineralization, there are multiple ways to intervene in this continuous process in order to stop or reverse the progression of the lesion. For this purpose, fluoride-containing products are used as the standard method of caries prevention**(3)**.

Laser irradiation increases the enamel acid resistance by mechanisms such as fusion, changing the crystallinity, and decreasing the permeability of enamel to chemical agents. It was reported that the physical, chemical, and kinetic alterations following laser irradiation can increase the penetration depth and substantivity of fluoride in the enamel structure**(4)**.

And hence, the application of fluoride compounds along with laser irradiation may result in formation of a more resistant enamel structure and, at the same time, minimize the unfavorable changes caused by laser irradiation. Simultaneous application of fluoride and laser to enhance enamel resistance has been previously studied[5].

Esthetics is an important aspect in dentistry and dental education. With the continuing advances in dentistry and dental technology, there are now an abundance of options that make it easy to perform esthetic dental procedures. The most conservative of all esthetic procedures is one that involves no tooth removal at all. This can be achieved by (minimal intervention dentistry) [6].

Few studies have been done to investigate the color improvement, this study was designed to compare the effect of laser and fluoride on the color of the white spot lesions.

AIM OF THE STUDY

The aim of this study is to compare the effect of using Er,Cr:YSGG laser and Sodium Fluoride gel 2% on the color change of the artificial white spot lesions of the primary teeth.

II. MATERIALS AND METHODS

Study Design and Setting

The study is an experimental in-vitro study that was conducted at the (laser center, Ain Shams University, Cairo, Egypt).

Sample Size Calculation

A power analysis was designed to have adequate power to apply a two-sided statistical test of the research hypothesis (null hypothesis) that there was no difference between the effect of Er,Cr:YSGG laser and Sodium Fluoride gel on the color change of white spot lesion on the primary teeth, which indicate the success of remineraliazation of the enamel. Assuming an alpha (α) level of 0.05 (5%) and a Beta (β) level of 0.20 (20%) i.e. power=80% and an effect size (f) of (0.52); The predicted sample size (n) was a total of (39) samples i.e. (13) for each group. Sample size calculation was performed using G*Power version 3.1.9.2 [7,8].

Sample grouping:

The study samples were randomly distributed between study groups according to the treatment methods (fig.1):

- Group A: (n=13) samples teeth that were exposed to 2% Sodium Fluoride gel.
- Group B: (n=13) samples teeth that were irradiated with a pulsed Er,Cr:YSGG laser.
- Group C: (n=13) samples teeth that were exposed to 2% Sodium Fluoride gel followed by Er,Cr:YSGG Laser.

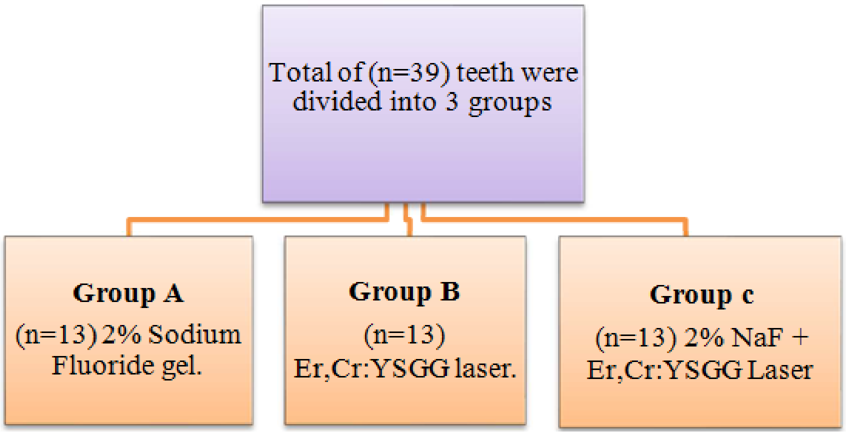


Figure 1: Study groups.

Teeth selected:

A total of thirty nine (N=39) freshly extracted anterior primary teeth were included in the study, the teeth were collected from the outpatient clinic of the Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Ain Shams University. Stored in normal saline[(7)].

Inclusion/exclusion Criteria:

Teeth were included in the sample according to the following criteria:

- Intact crown.
- Freed Enamel cracks or fractures.
- Free from caries, cavitated surface or white spot lesions[(7)].

Materials and devices:

Table 1: The materials used in this study

Material	Composition	Manufacturer
Demineralization solution.	50mM acetic acid, 2.2mM CaCl 2, and 2.2mM NaH2PO4.	Prepared at (Faculty of Pharmacy, Ain Shams University).
Ionite, Neutral PH Gel (fig.2).	Sodium fluoride gel 2%. 	DHARMA,USA
Artificial saliva.	Ca(NO3)2. 4H2O, NaH2PO4.2H2O, KCl, tris buffering, 0.03 ppm F.	Prepared at(faculty of pharmacy, Ain Shams University).
Cold cure acrylic resin.	Poly(methyl methacrylate). 	Acrostone dental, Egypt.

Material	Composition	Manufacturer
WaterLase® iPlus 2.0 Er,Cr:YSGG laser 2780nm (fig.3).		Biolase, USA.
Spectrophotometer (fig.4).		Shimadzu UV- 3101PC, (UV- VIS-NIR), USA.

Methodology:
Specimen preparation:

The root portion of each tooth was cut at 1 mm below the cementoenamel junction, and the crown was bisected by a diamond disk in a mesiodistal direction by using a double-sided diamond coated cutting disc (diameter 22mm, thickness 0.45mm) with a mandrel mounted a straight handpiece under continuous coolant[(9)](fig.2).

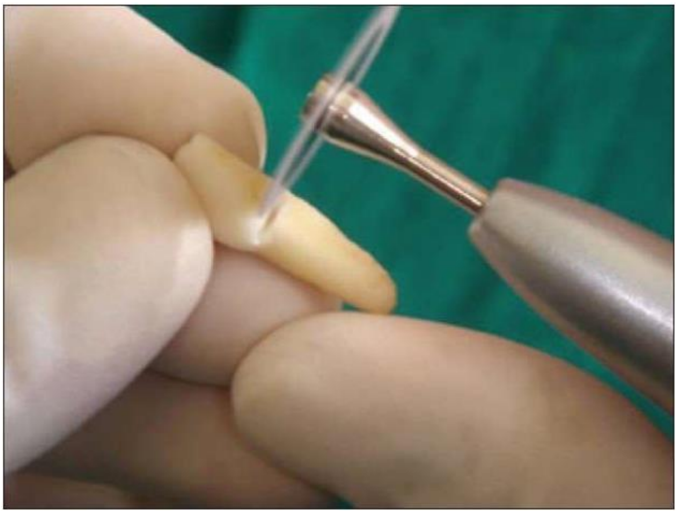


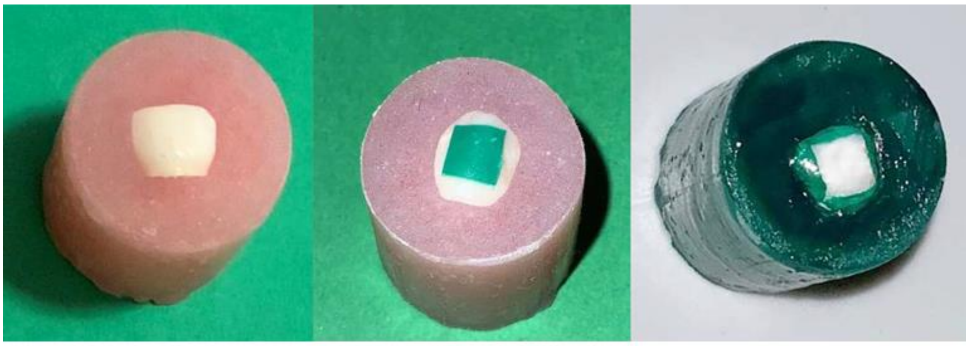
Figure 2: Cutting the root portion.

Cold cure acrylic resin was mixed in a glass container according to the manufacturer's instructions. It was then packed in a plastic of dimensions mould (diameter 22mm, height 15mm), the specimens were painted by a separating medium and put on a glass slab to obtain a flat surface, and then mounted on the top of the acrylic block to the labial surface facing upwards[9](fig.3,A).

The excess material was removed and another glass slab was placed on the top of the sample to make sure that the tooth is parallel to the horizontal plane.

After setting of cold-cure acrylic resin, 4*4 mm square of a self- adhesive tape (standard self-adhesive tape 0.17mm) was placed on the center of labial surface of the tooth[10] (fig3,B).

The whole block was painted by a double layer of nail varnish except the area covered with the adhesive tape to prevent any reaction of the acrylic material with the used solution or any particles precipitation on the tooth surface from the acrylic dissolution[10].



A B C

Figure 3: (A) Specimens were mounted on the acrylic block. (B) 4*4 mm square of a self-adhesive tape was placed. (C) The whole block was painted by a double layer of nail varnish.

After the dryness of the nail varnish, the adhesive tape was removed (fig.3,C).

Color measurement:

Color of each tooth was assessed by the CIE Lab system at 4 time points:

- T0: Color of natural enamel surfaces recorded (baseline examination,).
- T1: Color evaluation was performed again after demineralization (demineralization stage).
- T2: Color determination after 24hr of the assigned intervention (intense remineralization stage).
- T3: evaluation of color after 30 days of immersion in artificial saliva.

All the specimens were subjected to color measurements in Photometry Department, National Institute of Standards, Egypt[11].

The color of each specimen was assessed by the CIE Lab system, which was defined according to the International Commission on Illumination in 1967 and referred to as (Commission Internationale de L'Eclairage, 1978) in L*a*b* mode by using a spectrophotometer on the labial surface.

According to the manufacturer's recommendation, the spectrophotometer was calibrated on the white calibration tile. L* represents the value of lightness or darkness, a* represents the measurement along the red-green axis, and b* represents the measurement along the yellow-blue axis. The total color differences or distances between 2 colors (ΔE) were calculated using the following formula[12-13]:

$$\Delta E^* = \sqrt{\Delta L * 2 + \Delta a * 2 + \Delta b * 2}$$

Demineralization stage:

The demineralizing solution was performed at (faculty of pharmacy, Ain Shams University), it consisted of 50 mM acetic acid, 2.2 mM $CaCl_2$, and 2.2 mM NaH_2PO_4, pH 4.4[14,15].

The corresponding weight of each component of the demineralizing solution was measured by sensitive balance according to the molecular weight and volume prepared.

The weighted chemicals were dissolved in 1 liter of deionized- distilled water (DDW) by ultrasonic device for 10 minutes. The solution was stored in a Pyrex glass container covered with aluminum foil to avoid any reaction to light[16].

Artificial white lesion formation:

All teeth were immersed in the demineralizing solution in a closed glass container at room temperature for 96 hrs to create artificial white spot lesion (WSLs)[6].

After demineralization, color evaluation was performed again (demineralization stage, T1).

Remineralization stage:

The experimental groups were subjected to different treatments.

In group A (control group), 2% NaF gel (Ionite, Neutral PH Gel) enamel windows were treated with a fluoride for 4 minutes. Excesses was removed with a microbrush (fig.6,A)**[(11)]**.

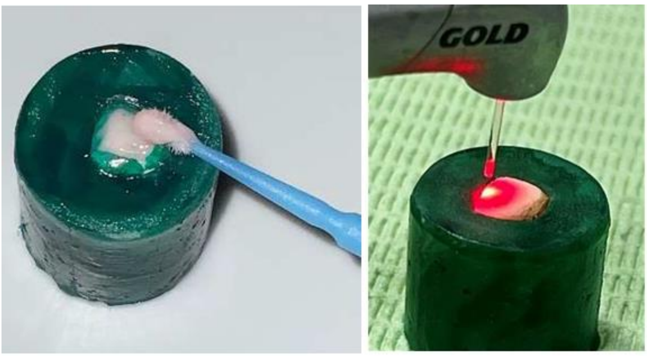
In group B, enamel windows were irradiated for 10 seconds with an Er,Cr:YSGG laser (Waterlase, Biolase Technologies Inc, San Clemente, Calif, USA) via the following settings (fig.4): Wave Length=2,780 nm, Power=0.50 Watt, pulse energy= 12.5 J/cm^2, repetition rate=20 Hz, pulse duration=140 micro second, 11% air; and 0% water. Using MZ6-Biolase tip, 600 µm in diameter (fig.5)**[(17)]**.

Figure 4: Setting of waterlase device

The laser tip will be positioned to the enamel surface at a distance of 1 to 2mm using the focused mode. The samples were irradiated by scanning and sweeping over all the white lesions (fig.6,B).


Figure 5: Biolase tip

In group C, a thin layer of 2% NaF gel (Ionite, Neutral PH Gel) was applied to the specimens for 4 min, and then was irradiated with the Er, Cr:YSGG laser for 10 seconds without removing the gel and left undisturbed for 2 min (fig.6,C)**[(17)]**.



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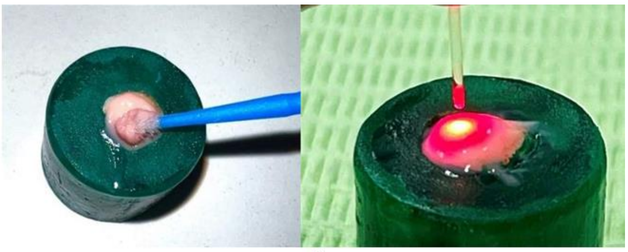

C

Figure 6: (A) Application of fluoride gel, (B) Enamel window was irradiated by Er,Cr:YSGG laser, (C) Enamel window was treated with a fluoride gel followed by Er,Cr:YSGG laser irradiation.

The teeth in all groups were rinsed thoroughly with tap water and were stored in artificial saliva, was performed at (faculty of pharmacy, Ain Shams University).

After 24 hours color was evaluated (remineralization stage, T2)[16].

All the specimens were restored in artificial saliva for 30 days and the saliva was changed every 48 hours[18].

After the 30-day interval, colour measurement was carried out, and L, a, and b values was recorded again (final measurement, T3).

The whole procedures were carried out by using single laboratory operator and the values were tabulated and subjected to statistical analysis.

Statistical analysis:

Numerical data were explored for normality by checking the data distribution, calculating the mean and standard deviation values and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed parametric distribution so; they were represented by mean and standard deviation (SD) values. One-way ANOVA followed by Tukey's post hoc test was used for intergroup comparisons while repeated measures ANOVA followed by bonferroni post hoc test was used for intragroup comparisons. The significance level was set at $P \leq 0.05$ within all tests. Statistical analysis was performed with IBM® SPSS® Statistics Version 26 for Windows.

III. RESULTS

A- Descriptive statistics:

Table 2: Descriptive statistics for color change (ΔE) in the study groups

Group	Interval	Mean	95%CI		SD	Median	IQR
			Lower	Upper			
Fluoride	T0-T1	4.22	4.00	4.43	0.29	4.11	0.38
	T1-T2	2.79	2.65	2.92	0.18	2.87	0.29
	T2-T3	0.70	0.60	0.80	0.14	0.71	0.16
	T0-T3	1.11	0.82	1.39	0.38	1.09	0.47
Laser	T0-T1	4.25	4.11	4.40	0.20	4.32	0.35
	T1-T2	1.89	1.79	1.98	0.13	1.88	0.10
	T2-T3	0.63	0.52	0.74	0.15	0.70	0.20
	T0-T3	1.93	1.79	2.06	0.19	1.95	0.25
Fluoride& Laser	T0-T1	4.21	4.03	4.39	0.24	4.24	0.35
	T1-T2	3.88	3.74	4.01	0.18	3.86	0.23
	T2-T3	0.84	0.71	0.98	0.18	0.83	0.26
	T0-T3	0.94	0.80	1.07	0.19	0.99	0.15

95%CI= 95% confidence interval for the mean; SD=standard deviation; IQR=interquartile range

B-Intergroup comparisons:

Mean and standard deviation (SD) values of color change (ΔE) for different groups were presented in table (3) and figures (7) and (8).

- ***T0-T1:***

There was no significant difference between different groups (p=0.944). The highest value was found in the laser group (4.25±0.20), followed by fluoride group (4.22±0.29) while the lowest value was found with fluoride& laser group (4.21±0.24).

- ***T1-T2:***

There was a significant difference between different groups (p<0.001). The highest value was found in the fluoride& laser group (3.88±0.18), followed by fluoride group (2.79±0.18) while the lowest value was found with laser group (1.89±0.13). Post hoc pairwise comparisons showed different groups to have significantly different values from each other (p<0.001).

- ***T2-T3:***

There was no significant difference between different groups (p=0.054). The highest value was found in fluoride& laser group (0.84±0.18), followed by fluoride group (0.70±0.14) while the lowest value was found with laser group (0.63±0.15).

- ***T0-T3:***

There was a significant difference between different groups (p<0.001). The highest value was found in the laser group (1.93±0.19), followed by fluoride group (1.11±0.38) while the lowest value was found with fluoride& laser group (0.94±0.19). Post hoc pairwise comparisons showed laser group to have a significantly higher value than other groups (p<0.001).

Table 3: Mean ± standard deviation (SD) for color change (ΔE) for different groups

Interval	**Color change (ΔE) (mean±SD)**			**p-value**
	Fluoride	**Laser**	**Fluoride& Laser**	
T0-T1	$4.22±0.29^{A}$	$4.25±0.20^{A}$	$4.21±0.24^{A}$	**0.944ns**
T1-T2	$2.79±0.18^{B}$	$1.89±0.13^{C}$	$3.88±0.18^{A}$	**<0.001***
T2-T3	$0.70±0.14^{A}$	$0.63±0.15^{A}$	$0.84±0.18^{A}$	**0.054ns**
T0-T3	$1.11±0.38^{B}$	$1.93±0.19^{A}$	$0.94±0.19^{B}$	**<0.001***

Different superscript letters indicate a statistically significant difference within the same horizontal row *; significant (p ≤ 0.05) ns; non-significant (p>0.05).

C-Intragroup comparisons:

Mean and standard deviation (SD) values of color change (ΔE) for different intervals were presented in table (4) and figures (9).

- ***Fluoride:***

There was a significant difference between different intervals (p<0.001). The highest value was found in (T0-T1) (4.22±0.29), followed by (T1-T2) (2.79±0.18), then (T0-T3) (1.11±0.38)) while the lowest value was found in (T2-T3) (0.70±0.14). Post hoc pairwise comparisons showed values found in (T0-T1) and (T1-T2) to be significantly different from each other and to be significantly higher than values found in other intervals (p<0.001).

- ***Laser:***

There was a significant difference between different intervals (p<0.001). The highest value was found in (T0-T1) (4.25±0.20), followed by (T0-T3) (1.93±0.19), then (T1-T2) (1.89±0.13) while the lowest value was found in (T2-T3) (0.63±0.15). Post hoc pairwise comparisons showed values found in (T0-T1) and (T2-T3) to be significantly higher and lower than values found in other intervals respectively (p<0.001).

- ***Fluoride & Laser:***

There was a significant difference between different intervals (p<0.001). The highest value was found in (T0-T1) (4.21±0.24), followed by (T1-T2) (3.88±0.18), then (T0-T3) (0.94±0.19) while the lowest value was found in (T2-T3) (0.84±0.18). Post hoc pairwise comparisons showed values

found in (T0-T1) and (T1-T2) to be significantly different from each other and to be significantly higher than values found in other intervals (p<0.001).

Table 4: Mean ± standard deviation (SD) for color change (ΔE) for different intervals

Group	**Color change (ΔE) (mean±SD)**				**p-value**
	T0-T1	**T1-T2**	**T2-T3**	**T0-T3**	
Fluoride	$4.22±0.29^{A}$	$2.79±0.18^{B}$	$0.70±0.14^{C}$	$1.11±0.38^{C}$	**<0.001***
Laser	$4.25±0.20^{A}$	$1.89±0.13^{B}$	$0.63±0.15^{C}$	$1.93±0.19^{B}$	**<0.001***
Fluoride& Laser	$4.21±0.24^{A}$	$3.88±0.18^{B}$	$0.84±0.18^{C}$	$0.94±0.19^{C}$	**<0.001***

Different superscript letters indicate a statistically significant difference within the same horizontal row *; significant (p ≤ 0.05) ns; non-significant (p>0.05)

IV. DISCUSSION

Enamel demineralization is a significant clinical problem that can lead to dental caries, which can result in tooth loss and oral pain. Despite the significant decline in caries incidence that has been exhibited in the past couple of decades. Still, caries continues to be the most prevalent disease in the field of dental health, particularly for children and adolescents. In this respect, attention should be directed towards resolving the problem, not only from the standpoint of restorative procedures but also in terms of preventive practice(19,20).

Considerable advances in caries prevention have been realized to search for the most cost-effective therapy. One of the most eminent scientific breakthroughs in the field of caries prevention is the discovery of fluoride. Effects of fluoride in caries prevention have been validated to be mainly on inhibiting demineralization and enhancing remineralization(21).

Fluoride is the most widely preventive method ever used, however it requires multiple applications over time (up to 6 months) to get a significant improvement and present a toxicity hazard as relatively large amounts of fluoride is given in unprecise doses to people(22).

Over the past twenty years, few in vitro studies have investigated the effect of using combined therapy of laser irradiation and topical fluoride application on enamel. These studies showed increased enamel hardness and fluoride uptake for the combined therapy groups versus fluoride-only treatment. Only a few studies looked at the esthetic effects of laser irradiation and topical fluoride treatment(22,23).

The use of laser irradiation for preventing dental caries is based on chemical, physical, and crystalline changes induced in enamel due to the heating of the surface. High-energy laser irradiation of enamel alone, at a specific wavelength, has been shown to cause remineralization. Various explanations have been proposed, One theory states that laser irradiation decreases enamel permeability due to the physical fusion of the enamel surface microstructure(24,25).

Another theory has focused on a combination of reduced enamel permeability with reduced solubility promoted by melting, fusion, and recrystallization of enamel crystallites, which seals the enamel surface. Reduction in enamel solubility could be due to ultra-structural changes in the crystallography of enamel. There is also a reduction of water and carbonate content, an increase in the hydroxyl ion contents, formation of pyrophosphates, and decomposition of proteins(24,25).

Many techniques have been used to evaluate the effectiveness of several processes and agents on acid resistance of teeth. These include the evaluation of structural changes as well as measurements of color recovery, microhardness, mineral loss, and calcium, phosphate, and fluoride level(26,27).

Subsequently, the objective of this study was to compare the effect of using Er,Cr:YSGG laser, and sodium Fluoride gel on the color change of the white spot lesions.

Thirty three extracted primary anterior teeth in each of the experimental groups was sufficient to evaluate the effect of Er,Cr:YSGG laser, and sodium Fluoride gel on the color change of the white spot lesions based on statical analysis. All teeth were selected with non-carious, non-discolored, free of cracks or defective enamel for standardization between groups. All primary teeth were stored in normal saline before being used to prevent dehydration that could have affected the measurements as well as for standardization.

In this study artificial caries formation was chosen as it takes less time, can measure baseline color before creation of artificial caries and is more uniform than natural caries, in addition to being reproducible. It was performed by immersing the teeth in the demineralizing solution (pH 4.4) for 96 h. This method was followed as many studies used it for caries formation in primary teeth(6).

In the present study, color measurement was done using a spectrophotometer. The instrumental color analysis offers a potential advantage over visual color determination because instrumental readings are objective, can be quantified, and are more rapidly obtained. Spectrophotometers are among the most accurate, useful, and flexible instruments for color matching, that function by measuring the spectral reflectance or transmittance curve of a specimen(6).

The results of this study showed that there was a color difference between the baseline and demineralization stages (ΔE T0–T1) was greater than 4.2 units in all groups, indicating the creation of clinically visible white spot lesions(6). There was no statistical difference in ΔE T0–T1 among the experimental groups, which was a necessary condition for proper comparison of treatment effects on carious enamel.

Following the intense remineralization regimen (T2), which included fluoride, laser and fluoride followed by laser treatment(11). The color change between the demineralization and intense remineralization stages (ΔE T1–T2) was significantly greater in (group C) sodium fluoride gel followed by laser application (3.88±0.18), followed by fluoride group (group A) (2.79±0.18) while the lowest value was found with laser group (group B) (1.89±0.13).

The final measurement was after 30 days (T3), The color change between (ΔE T0–T3) was a significant difference between different groups. The highest value between baseline examination (T0) and final examination (T3) was found in the laser group which is did not return to baseline color (1.93±0.19), followed by fluoride group (1.11±0.38) while the lowest value was found with fluoride& laser group(0.94±0.19) which is was almost return to the baseline.

The results came in agreement with the study by **Poosti et al.(2014)**[26] who also used the Commission International de l'Eclairage (CIE) lab system in the study, concluded that the application of a fractional CO2 laser either before or through the acidulated phosphate fluoride gel (APF) was more effective in restoring the appearance of carious enamel after a 90-day remineralization period compared to acidulated phosphate fluoride alone and control groups.

In accordance to **Kumar et al. (2016)[28]** evaluated and compared the surface microhardness and surface morphology of permanent tooth enamel after Er,Cr:YSGG laser irradiation and fluoride application. Their results showed that Er,Cr:YSGG laser irradiation alone or in combination with fluoride gel is an effective tool to provide resistance against caries. Significantly higher resistance was seen when APF gel was used prior to Er,Cr:YSGG laser irradiation and this combination can act as an efficient tool for prevention against dental caries.

In addition, **Assarzadeh et al (2021)[4]** , agreed that Er:YAG laser irradiation changes the chemical composition of enamel and probably promotes its remineralization, especially when combined with APF gel application, and increases fluoride uptake and decreases its permeability.

Alqahtani et al (2021)[23] reported that combination therapy of diode laser irradiation with topical fluoride application significantly improved the esthetic appearance of WSLs versus control and fluoride-only groups.

Eissa et al. (2022)[29] came up with similar results, stating that coating the enamel surface with sodium fluoride plus tricalcium phosphate vanish followed by CO2 laser irradiation acted as a protective layer from the undesirable effects of laser on the teeth with increasing enamel microhardness values more than using Vanish alone.

The results of **Molaasadollah et al. (2017)[7]** came in disagreement as they found that the combination of laser and fluoride gel was not significantly different from the application of fluoride gel alone in enhancing the remineralization of WSLs. Their study was conducted on different laser settings and the teeth were sectioned to three sections were made of each tooth at the site of WSLs.

And the results came in agreement with the fluoride group by **Kim et al. (2013)[30]** which determined the color of white spot lesion by using CIE L*a*b* color parameters through spectroradiometer, while using different concentration of sodium fluoride and found that fluoride partially restore the color of white spot lesions.

In addition, **Kaur et al.(2017)[31]** with regard to laser group they evaluate the changes on the enamel surface and microhardness around orthodontic brackets after surface treatment by CO_2 laser, Er, Cr:YSGG laser and fluoride varnish in vivo, and found that the surface treatment with Er,Cr:YSGG laser causes a positive alteration of the enamel surface increasing its ability to resist demineralization with optimum microhardness as compared to CO_2 laser and sodium fluoride varnish.

El Mansy et al.(2019)[32] Compared the effect of Er, Cr: YSGG and nanosecond Nd: YAG laser on enamel acid resistance. The results showed that both Er, Cr: YSSG and nanosecond Nd: YAG laser irradiation were able to improve the acid resistance of enamel. However, enamel surface treated with Er, Cr: YSSG laser showed the lowest mean percentage decrease of calcium and phosphorus (highest acid resistance).

In our study the combination of sodium fluoride gel with Er, Cr:YSGG laser was the best result in color improvement, which lead to less consumption of fluoride amount. However, there was not well defined parameters for the application of laser, and there was not enough studies about esthetic improvement of white spot lesions by using the combination of fluoride and laser.

V. CONCLUSION

Based on the results this study, it can be concluded that: The irradiation of WSLs with Er, Cr:YSGG laser through the NaF gel was more effective in improving the appearance of white spot lesions. Fluoride alone is less effective in improving the appearance than combined laser an fluoride. Er, Cr:YSGG laser alone was the lowest effective in restoring the appearance of white spot lesions.

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