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Amani A. Bin Shahna

*PhD candidate for Operative Dentistry Faculty of Dental Medicine for Girls Al-Azhar University and
Lecturer at Conservative Department Faculty of Dentistry Aden University, Yemen,
msamani554@gmail.com*

Wael E. Gamel

Professor of Operative Dentistry Faculty of Dental Medicine for Girls Al-Azhar University

Asmaa A. Mosleh

Lecturer of Operative Dentistry Faculty of Dental Medicine for Girls Al-Azhar University

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Clinical Efficacy of Combined Application of Diode Laser and Different Remineralizing Agents on White Spot Lesions

Amani A. Bin Shahna ^{a,*}, Wael E. Gamel ^b, Asmaa A. Mosleh ^b

^a Conservative Department Faculty of Dentistry Aden University, Yemen

^b Operative Dentistry Faculty of Dental Medicine for Girls Al-Azhar University, Cairo, Egypt

Abstract

Purpose: The current study was conducted to clinically assess the efficacy of concomitant application of Diode Laser with different remineralizing materials (Remin Pro, X Pur Remin, and Pro-fluoride varnish) on white spot lesions. **Materials and methods:** A single-blinded, parallel-group, randomized clinical trial design was followed. Forty-five teeth with white spot lesions (WSLs) were selected from 30 patients who attended the outpatient clinic of the Operative Dentistry department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt. The participants were randomly assigned into three groups according to the applied treatment agent: Remin Pro, X Pur Remin, and Pro-fluoride varnish. Treatments in all groups were combined with diode laser application (801 nm, 1W, continuous mode). The color changes of WSLs were evaluated before application (T₁), immediately (T₂), and after one month (T₃) by using an Easy shade V spectrophotometer. **Results:** Mann–Whitney's test revealed statistically significant differences between the experimental groups at all-time intervals (sound tooth was significantly higher than white spot lesion). Remin Pro was significantly the highest at T2-T3 and T1-T3. There was none statistically significant difference between X Pur Remin and Pro-fluoride varnish for the sound tooth. Conversely, at T2-T3 and T1-T3 Pro-fluoride, the varnish group showed the highest statistically significant difference. There was none statistically significant difference between Remin Pro and X Pur Remin in white spot lesions. **Conclusion:** Diode laser irradiation (801 nm, 1W, continuous mode) can improve in terms of the color change of white spot lesions of enamel.

Keywords: Diode laser, Vita easy shade V, White spot lesion

1. Introduction

Dental caries is a very common condition and represents a serious public health risk. It can be manifested as micro-molecular initial apatite crystals that change to apparent White Spot Lesions (WSLs) or eventual cavitation. The white spot lesion looks chalky because minerals are lost from the surface and the underside of the enamel. Continuous imbalance among protective and pathological factors results in demineralization and caries progression through the previously mentioned stages [1].

Various devices and software have been utilized in measuring tooth color change following the

application of esthetic materials, such as colorimeters, spectrophotometers, and image-analysis soft wares. Loss of normal enamel translucency is the most characteristic feature of WSL due to light absorption and scattering at the porous and rough surface [2].

Besides, the attempts to treat the WSLs using Diode Laser alone or with concomitant topically applied fluoride can be considered a simple and noninvasive caries preventive measure, resulting in decreased solubility and demineralization of tooth tissue [3].

A remineralizing water-based cream called Remin Pro (VOCO GmbH in Cuxhaven, Germany) contains hydroxyapatite, fluoride, and xylitol. It has been claimed that xylitol works as an antibacterial agent, fluoride plugs dentinal tubules, and

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* Corresponding author. Operative Dentistry Faculty of Dental Medicine for Girls Al-Azhar University, Egypt. Fax: +23878053.

E-mail address: msamani554@gmail.com (A.A. Bin Shahna).

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hydroxyapatite fills eroded enamel. According to considerations, this product can be used to treat dentinal hypersensitivity, stop enamel from demineralization, and encourage remineralization of subsurface enamel lesions [4].

An idea that Sangi first described in developing the first nanohydroxyapatite remineralizing tooth-paste was to support a naturally occurring function and the therapeutic role of saliva in the mouth [5]. Nano-medical hydroxy-apatite particles fill the enamel subsurface vacancies, supplying calcium and phosphate ions to the regions from which minerals have been lost and restoring internal enamel crystals' lattice structure, translucency, and integrity [6]. Therefore, this study was conducted to assess the efficacy of the application of diode laser with the remineralizing agents on the color of WSLs.

2. Materials and methods

2.1. Selection of the patients

The study was reviewed and approved by the 'Ethical research committee' of the faculty of Dental Medicine for girls; at Al-Azhar University, Cairo, Egypt (REC-OP-23-1). This study was conducted on 45 teeth with white spot lesions (WSLs) detected clinically on the buccal surface of the teeth. Patients had WSLs were selected randomly from the operative dentistry clinic, Faculty of dental medicine, Girl's Branch, Al-Azhar University, after explaining the benefits/risks of applying the intervention and control. The patients were subjected to complete examination and diagnosis using dental charts. The patients potentially eligible for this study were identified, and the researcher explained the research to them and ascertain their interests. Written informed consents from the patients were obtained after they clarified the study protocol and methods.

2.2. Inclusions and exclusions criteria [7]

Patients had white spot lesions were identified based on the history, clinical examination, inclusions, and exclusions criteria. Inclusions criteria included the following: The patients should be 13–40 years old. The patients should have good oral hygiene, general health, and no systemic disease. On the other hand, exclusions criteria included the presence of enamel hypoplasia, dental fluorosis, and carious cavity. These patients have diminished salivary flow or significant tooth wear, and concurrent participation in other clinical trials.

2.3. Grouping of patients

After examination, the teeth were assigned into three groups of 15 teeth with white spot lesions, each according to the remineralizing material used:

Group 1: use a pea-sized amount of Remin Pro with a brush and applied on the tooth surface for at least 3 min according to the manufacture instructions. Patients were instructed to avoid rinsing, eating, and drinking for 30 min.

Group 2: a thin film of X Pur Remin was applied by the micro brush on the tooth surface for 3 min. Do not eat, drink or rinse for 30 min.

Group 3: a thin film of VOCO Pro-Fluoride Varnish was applied on the tooth surface using a brush applicator. The area was kept wet (either by gentle rinsing or natural salivary flow) to ensure the setting of VOCO Pro-Fluoride Varnish.

2.4. Patients' preparations

After routine dental cleaning and scaling, debris of periodontal tissue remnants and blood were washed with water. This procedure was followed by dental polishing using fine pumice paste and rubber cup tips at low rotational speed and vigorous water coolant. Protection of gingival tissues of the offending teeth was done using a light-cured gingival liquidam, to ensure complete protection of the gingiva from any inadvertent exposure to laser irradiation. Lips and cheeks protection was done through the application of lip and cheek retractor [7].

2.5. Study intervention and clinical procedures

A photosensitizing-remineralizing agent mixture was prepared by adding pre-green dye (0.05 ml) to 1 mg of the assigned remineralizing agents. For the preparation of the photosensitizing dye material, an Elexxion Perio Green tablet (*Elexxion AG, Otto-Hahn-Straße 7, 78, 224 Singen, Germany*) with 0.2 mg indocyanine green was added to 2 ml of sterile water, followed by vigorous manual shaking until the active agent tablet has completely dissolved and a clear, green liquid has formed. This process takes approximately 60 s [8]. After the protection of the gingiva, the photosensitizing-remineralizing agent was placed on enamel surface according to the assigned group.

The diode laser (*AMD LASERS Picasso Plus, Indonesia*) was irradiated immediately with average power of 1W, Exposure time of 10 s, diode 810 nm, continuous and noncontact mode, and irradiation speed of 1 mm/sec [9]. The Tip Handpiece was



Fig. 1. Laser application.

moved by the operator tangentially (45-degree angle). Laser irradiation as represented by (Fig. 1), was performed with a noncontact mode and sweeping motion to cover the spot's whole surface. After 5 min of applying the photo-absorbing gel, teeth were washed for 1 min using 10 ml of deionized water, and then air dried [10].

2.6. Spectrophotometric color assessment

The Vita Easy shade (Vita Zahnfabrik, Bad Säckingen, Germany) was utilized to assess the color change of white spots lesions. Device calibration before each assessment session was done with the aid of a white table provided with the manufacturer (Figs. 2 and 3). The probe tip was held perpendicular to the surface [11] (Fig. 4).

2.7. Statistical analysis

Statistical analysis was performed with SPSS 20®, Graph Pad Prism®, and Microsoft Excel 2016. All data were explored for normality by using Shapiro Wilk and Kolmogorov Normality test and presented as means difference and standard deviation (SD)



Fig. 2. Main menu.



Fig. 3. Measurement results.

values. Data originated from non-parametric data regarding laser in sound tooth and white spot lesions in all groups. Accordingly, a comparison between different groups was performed using the Kruskal Wallis H test. Also, a comparison between different intervals was performed using the Friedman's test.

3. Results

3.1. Comparison between different groups to evaluate the effect of the material

The mean difference and standard deviation between different intervals in sound tooth and white spot lesions regarding laser were presented in (Table 1).

The Comparison between different groups was performed using Kruskal Wallis H test, the results revealed that.

- (1) **Sound tooth:** There was nonstatistically significant difference between all groups at T1-T2, while at T2-T3 and T1-T3, there was a statistically significant difference between groups.



Fig. 4. Color measurement.

Table 1. Comparison between different groups to evaluate the effect of the materials.

	Remin Pro		X Pur Remin		Pro-fluoride varnish		P value
	MD	SD	MD	SD	MD	SD	
Sound tooth							
Laser							
T1-T2	−0.01 ^a	0.10	0.00 ^a	0.00	0.00 ^a	0.00	0.15
T2-T3	1.76 ^a	0.51	0.63 ^b	0.51	0.43 ^b	1.82	0.005*
T1-T3	1.75 ^a	0.51	0.63 ^b	0.51	0.43 ^b	1.82	0.005*
White spot lesion							
Laser							
T1-T2	−0.85 ^a	0.29	−0.29 ^b	0.16	−0.35 ^b	0.15	<0.0001*
T2-T3	−1.15 ^a	0.37	−1.33 ^a	0.60	−0.35 ^b	0.75	<0.0001*
T1-T3	−2.01 ^a	0.54	−1.62 ^a	0.59	−0.70 ^b	0.82	<0.0001*

MD, mean difference; SD, standard deviation.

P: probability level which is significant at $P \leq 0.05$.Counts with the same superscript letters were insignificantly different as $P > 0.05$.Counts with different superscript letters were significantly different as $P \leq 0.05$.

Remin Pro was significantly the highest, and there was nonstatistically significant difference between X Pur Remin and Pro-fluoride varnish.

- (2) **White spot lesion:** There was a statistically significant difference between all groups. Remin Pro was significantly the lowest at T1-T2, while there was a nonstatistically significant difference between X Pur Remin and Pro-fluoride varnish at T2-T3 and T1-T3. Pro-fluoride varnish was significantly the highest, while there was a nonstatistically significant difference between Remin Pro and X Pur Remin.

3.2. Comparison between different intervals to evaluate the effect of time

The mean difference and standard deviation between different intervals in sound tooth and white spot lesions regarding laser groups were presented

in (Table 2); comparison between the different time intervals was performed using the Friedman test.

(1) Sound tooth

In Remin Pro: There was a statistically significant difference between different intervals, the mean differences with the superscript letter (a) were significantly the highest (T2-T3 and T1-T3), and the mean difference with the superscript letter (b) was significantly the lowest (T1-T2).

In X Pur Remin: There was a statistically significant difference between different intervals with laser groups, the mean differences with the superscript letter (a) were significantly the highest (T2-T3 and T1-T3), the mean differences with the superscript letter (b) were significantly the lowest (T1-T2 laser and without laser).

In Pro-fluoride varnish: There was a statistically significant difference between different intervals

Table 2. Comparison between different intervals to evaluate the effect of time.

	Remin pro		X Pur Remin		Pro-fluoride varnish	
	MD	SD	MD	SD	MD	SD
Sound tooth						
Laser						
T1-T2	−0.01 ^b	0.10	0.00 ^b	0	0.00 ^b	0
T2-T3	1.76 ^a	0.51	0.63 ^a	0.51	0.43 ^a	1.82
T1-T3	1.75 ^a	0.51	0.63 ^a	0.51	0.43 ^a	1.82
P value	0.05*		<0.0001*		<0.0001*	
White spot lesion						
Laser						
T1-T2	−0.85 ^c	0.29	−0.29 ^c	0.16	−0.35 ^b	0.15
T2-T3	−1.15 ^b	0.37	−1.33 ^b	0.60	−0.35 ^b	0.75
T1-T3	−2.01 ^a	0.54	−1.62 ^a	0.59	−0.70 ^a	0.82
P value	0.0004*		<0.0001*		<0.0001*	

MD, mean difference; SD, standard deviation.

P: probability level which is significant at $P \leq 0.05$.Counts with the same superscript letters were insignificantly different as $P > 0.05$.Counts with different superscript letters were significantly different as $P \leq 0.05$.

with laser group, the mean differences with the superscript letter (a) were significantly the highest (T2-T3 and T1-T3), furthermore the mean difference with the superscript letter (b) was significantly the lowest (T1-T2).

(2) White spot lesion:

In Remin Pro: There was a statistically significant difference between different time intervals with laser groups, the mean difference with the superscript letter (a) was significantly the lower (T1-T3), followed with the mean difference with the superscript letter (b) (T2-T3). At the same time, the mean difference with the superscript letter (c) was significantly the highest (T1-T2).

In X Pur Remin: There was a statistically significant difference between different time intervals with laser groups, the mean difference with the superscript letter (a) was significantly the lower (T1-T3), followed with the mean difference with the superscript letter (b) (T2-T3), while the mean difference with the superscript letter (c) was significantly the highest (T1-T2).

In Pro-fluoride varnish: There was a statistically significant difference between different time intervals with laser groups, the mean difference with the superscript letter (a) was significantly the highest (T1-T3). In contrast, the mean differences with superscript letter (b) were significantly the lowest (T1-T2 and T2-T3).

4. Discussion

The current study investigated the clinical efficacy of the combined application of diode laser and different remineralizing agents on white spot lesions. Since there are many factors that play a crucial role in caries progression, such as diet, fluoride, and oral hygiene measures that adversely affect its prevention [12], the current study was contemplated for four.

Demineralized enamel surface appears whitish due to the difference in the refractive indices (RIs) between defective and sound enamel, which causes light to scatter, resulting in a whitish opaque appearance of those lesions, especially when they are desiccated. Micro-porosities present in the affected enamel lesions are what cause this difference. Unlike sound enamel, which has a (RI of 1.62), these micro-porosities are filled with either water (RI = 1.33) or air (RI = 1.0). When these pores are wet, the lesions are opaque compared to the healthy tissue, but when they are dried, they fill with air, making the lesion more evident and noticeable [13].

Diode laser selected in the present study as it has an enamel remineralizing potential, reduces enamel permeability, and results in re-crystallization and entanglement of its apatite crystals. Besides, it reduces the enamel content of carbonates which are soluble and is weakly bonded to hydroxyapatite crystals [14]. A photon-absorption enhancer cream (Perio- Green Dye) was used prior to laser exposure to promote the photo-chemical response and enhance absorption of laser by the tooth tissue since diode lasers are known for their low absorption by tooth enamel. This condition encouraged previous researchers to apply several photo-absorbing agents, such as; Indocyanine Green (ICG) in conjunction with diode laser at the infrared spectrum [15]. Several investigations validated the clinical accuracy of Vita Easy shade spectrophotometer. It was used to analyze the ΔE value and quantifying the discrepancy between the two colors [16].

This study revealed that, Pro-fluoride varnish was statistically significantly the highest at T2-T3 and T1-T3 for the color change because the lesion depth regression is complex due to the slow diffusion process; the diode laser was applied to pro-fluoride varnish to enhance fluoride diffuse-ability, that in turn causes more ions uptake in enamel and facilitate ions-linking in the surrounding area [17]. This result agrees with other studies [18,19], which revealed a statistically significant improvement in aesthetic appearance of white spot lesions when 940 nm diode laser (2W for the 60 s), was used concurrently with fluoride, as compared to the control and fluoride monotherapy groups. However, another study [20] revealed no a statistically significant change in the esthetic appearance when 810 nm diode laser (2W in continuous mode), was administered in conjunction with fluoride in comparison to the sole fluoride application, because this study used the difference in the materials and methods.

Conversely, Remin Pro was statistically significantly the lowest at T1-T2, while there was no a statistically significant difference between X Pur Remin and pro-fluoride varnish for the color change; these might be due to the different change of the chemical structure of the demineralization of WSLs of each tooth in the current study, which eliminate a considerable amount of calcium and phosphate enamel contents, for that reasons, Remin pro cannot replace calcium and phosphate loss, hence the color was not improved. These findings are agreed with some studies [21,22]; they reported that enamel content of calcium wasn't changed among study groups using diode laser application and photon-absorption enhancer cream, the authors

attributed the decrease in phosphorous content following laser application to its volatility as a result of the generated heat during laser irradiation procedure.

Nevertheless, they used a high-power of Nd: YAG lasers. On the other hand, this result did not agree with study [10], which concluded that the concurrent administration of diode laser with Remin Pro was efficient on the remineralization, because an improvement in calcium and phosphate ratio was detected with the combined use of laser irradiation and Remin Pro. Another study [23] found that the Remin Pro application effectively reduced the area, increased the mineral content, improved effectiveness in reducing the size, increasing the mineral content, and improving the appearance of demineralized enamel. These suggest that products may be indicated for managing post-orthodontic WSLs.

On the other hand, in the Nano-HA (X Pur Remin) group, there was a nonstatistically significant difference at T2-T3 and T1-T3 for the color change because more minerals may accumulate on the lesion's surface than in its body. Then, this new highly mineralized surface layer can stop minerals from moving into the deep parts of the lesions and does not improve their color in every way [24]. On the other hand, after treatment of bleached enamel using carbon dioxide laser and nanohydroxyapatite administration for one day, it results in a decrease of surface roughness and porosity. The reduction of surface roughness after 60 days was more than one day, as the carbon dioxide laser irradiation caused surface fusion and smooth re-crystallized feature [25].

On the other hand, Remin Pro was significantly the highest. There was nonstatistically significant difference between X Pur Remin and Pro-fluoride varnish with sound tooth, this finding may be related to the thermal effects of laser beams produce cracks in enamel. It increases the penetration of hydroxyapatite and fluoride into any porosities on the enamel surface [26].

4.1. Conclusions

Within the limitation of this study, it was concluded that.

- (1) White spot lesions of the enamel might be improved in terms of color change using diode laser irradiation (801 nm, 1W, continuous mode) for a month.
- (2) Pro-fluoride varnish improved the color of white spots lesions compared to other materials,

whereas, Remin Pro had the best color enhancement with sound teeth.

4.2. Recommendations

Further, clinical trial studies are needed to investigate the long-term effects of diode lasers on the recovery of WSLs.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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