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RESEARCH ARTICLE

STUDY OF THE EFFECT OF FLUORIDE ON LASER ENHANCED REMINERALIZATION OF DEMINERALIZED HUMAN ENAMEL

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Abstract

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Background: Enamel is regularly subjected to demineralization and remineralization under different oral circumstances. Any interruption in the balance between demineralization and remineralization can initiate the formation of incipient caries lesions. However, in the early stage of formation these lesions can be remineralizedusing various preventive measures. Topical fluorides have shown positive results in the prevention of caries in several studies. The aim of this study was to determine the effects of combination between diode laser and topical fluoride application on the surface microhardness of the demineralized enamel.

Materials and Methods: Four caries-free human premolars were examined under the stereomicroscope to exclude teeth with surface enamel defects. Buccal enamel surface microhardness (SMH) for all samples was measured by Micro Vickers Hardness Tester (MVHT). The samples were demineralized by 15% Hydrochloric acid (HCl) with PH average 4.5, then the SMH was measured. The demineralized teeth were subjected to fluoride toothpaste after diode laser application. Third evaluation for enamel SMH was performed after remineralization.

Results: Enamel SMH of the control group has shown the highest values followed by the remineralization group while the least values were measured in the demineralization group.

Conclusions: The results obtained in the study lead to the conclusion that application of fluoride toothpaste after diode laser could enhance the remineralization potential of the demineralized enamel.

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Introduction:-

Dental Caries is a one of the common preventable widespread oral disease diseases which is the primary cause of oral pain and tooth loss. Although dental caries is complex multifactorial process, however, it can be arrested and reversed in its early stages ***(Petersen, 2003; Pitts, 2004).*** Caries progression or reversing depends on the equilibrium between the demineralization and remineralization ***(Konig, 2004).***

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Remineralization can occur as a natural repair process where calcium and phosphate ions are deposited into crystal gaps of the demineralized tooth structure. Moreover, aided remineralization where ions are directly delivered to where and when they are needed most. The most popular aided remineralization mechanism is the delivery of topical fluoride ***(Featherstone, 1999; Marthaler, 2004)***.

Theoretically, caries can be prevented by proper oral hygiene and sugar moderation. However, practically, effective caries prevention is still not realistic without fluoride application in various procedures. There is an increasing evidence that the effect of fluoride is mainly the result of chemical reactions on the tooth surface. Hence, fluoridated toothpastes, gels, varnishes, and rinses are more crystal-clear in this matter ***(Zimmer et al., 2003)***. Additionally, the use of topical fluoride is becoming the primary approach. As the restorative treatment of caries is relatively expensive, and fluoride has proven to be efficient in caries reduction, it remains considered a standard for caries prevention **(*Šket et al., 2017*).**

Irradiation of dental enamel by CO_2 laser alters the hydroxyapatite crystals reducing the acid reactivity of the mineral; CO_2 laser irradiation in combination with fluoride treatment is more effective in inhibiting caries-like lesions than CO2 laser irradiation or fluoride alone ***(Rodrigues et al., 2004).*** Combined laser and topical fluoride treatment was effective for reducing the incidence of caries in vivo ***(Zezell et al., 2009).***

It has been indicated that many laser systems including diode lasers have shown promising results in enamel remineralization and caries prevention ***(Karandish, 2014).*** Furthermore, researches demonstrated a significant synergism between fluoride and laser in enamel solubility reduction ***(Noureldin et al., 2016).***

Despite the positive indications in the literature about the credibility of laser irradiation as a synergistic to topical fluoridation for enamel caries prevention, an inadequate level of evidence was found concerning the lasers' effectiveness in preventing caries. Further studies with a higher methodological quality level are required ***(Pagano et al., 2020)***. Further research should be focused on selecting proper laser settings to avoid damage to enamel and developing effective evidence-based clinical protocols ***(Al-Maliky et al., 2020)***. Accordingly, the aim of the present study is to evaluate the effect of fluoride containing tooth paste on a specific diode laser enhanced remineralization of the demineralized human enamel.

Materials and Methods:-

Four caries-free human premolars extracted for orthodontic reasons collected from private clinic. Teeth were examined under the light stereomicroscope to exclude teeth with cracks, abrasions and decay on the buccal surfaces. Teeth were stored in distilled water to prevent changes in the surface structure or the mineral properties of the enamel.

Sample preparation:

4 mm² window was marked on the middle third of the buccal surface of each premolar. Teeth were coated with acid resistant nail varnish, leaving the middle third of the buccal surface of enamel exposed to receive all the treatments of the experiment and to be examined ***(Vlacic et al., 2007).***

Control Group (group I):

The surface microhardness (SMH) was measured using Micro Vickers Hardness Tester (MVHT) in three different areas (The results of the samples were considered as control group values **"group I"**).

Demineralization Group (group II):

The same samples were subjected for 5 minutes to demineralizing agent (hydrochloric acid) 1.0 mole per liter (M) hydrochloric acid, 15% dilution**.** The PH of the acid was adjusted to average 4.5**.** The specimens were rinsed with deionized water and dried with absorbent paper. SMH was measured after demineralization (to record the demineralization group values).

Remineralization Group (group III):

The demineralized samples were subjected to diode laser at 980 nm for 30 seconds. Diode laser device model is (Simpler laser) with wavelength of 980nm purchased from the dental company Doctor smile, made in Italy.

After irradiation, specimens in each group were stored in distilled water. The irradiated samples were subjected to sodium fluoride (Sensodyne toothpaste). The brushing was performed with a fixed rate (120 strokes/min) for 140 seconds, simulating 2 weeks of brushing twice daily for 5 seconds ***(Tschoppe et al., 2011).*** The toothpaste was mixed with distilled water with a ratio of toothpaste: water 2:1. ***(Bergesch et al., 2017)***. After tooth brushing, specimens were rinsed in water to ensure removing all the toothpaste. All specimens were tested by MVHT to record the values of the remineralization group (Group III).

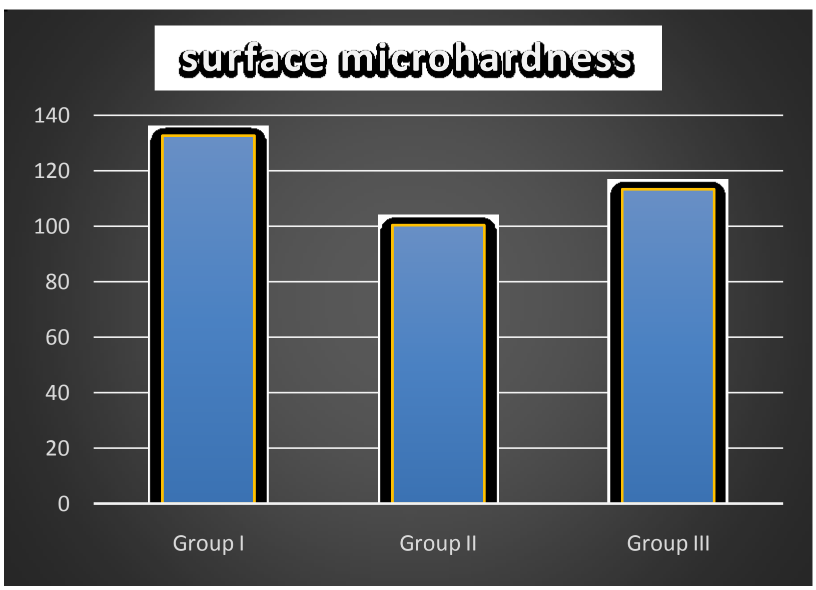
Remineralizing paste:
Fluoride containing toothpaste (1426 ppm Fluoride), purchased as Sensodyne fluoride toothpaste, manufactured by Eva Cosmetics Corp.

The surface microhardness (SMH):
SMH of the specimens were measured as Vickers hardness number (VHN) using an automatic digital microhardness tester (Micro Vickers Hardness Tester, Data was tabulated and represented by mean and standard deviation and bar charts.

Results:-
The measurement of the surface enamel microhardness using Vicker's Hardness Tester has shown the descending sequence of the tested groups as follows: Control, fluoride and demineralizing group respectively, showing that the surface microhardness of the samples increased after being treated with fluoride but did not reach the surface microhardness values of the control group **(Table 1, Bar chart 1).**

Table (1):- Mean and standard deviation of Vicker's Microhardness values of all groups:

	Control	Demineralization	Remineralization
	Group I	**Group II**	**Group III**
Mean	132.6675	100.3975	113.335
STD	2.535	8.290369413	5.972182739



Bar chart (1):- Showing Mean values of Vicker's Microhardness measurements of all groups.

Discussion:-
The present study focused on the remineralization as an effective tool for reversing an initial caries, consequently, aids in caries prevention which is an important aim in the dental field. Although the enamel remineralization potential and its role in caries arresting are widely discussed in the literature ***(Abou Neel et al., 2015***), there is a controversy about the categorization of the remineralizing materials as well as the enhancing techniques for the application of these materials ***(Hussein and El-Haddad, 2018).***

In this study fluoride paste is used as a remineralizing agent enhanced by diode laser application. We selected the low energy laser (diode laser) because of low cost, easy handling, being portable and of no heavy weight. High energy lasers were costly, time consuming and need sustainability ***(Awooda and Almuslet, 2015).*** The initiation of incipient enamel caries like lesions in this study was performed by applying a demineralizing acid due to its simplicity, low cost and experimental stability. ***Lucchese and Gherlone (2013)***, demonstrated that HCL erodes the surface effectively.

The current study presented significant statistical decrease in microhardness values of the enamel surface after artificial incipient carious lesions formation from normal enamel. By treatment with fluoride paste the Vicker's microhardness tester has shown a significant increase in the microhardness values of enamel surface.

This finding was in agreement with several studies have reported the beneficial effects of laser produced radiation on enamel in combination with fluoride ***(Klein et al., 2005; Castellan et al., 2007).*** The increase in the surface microhardness observed after treatment with fluoride group agreed with ***De Sant' et al., (2007)*** who revealed that irradiation from an infrared diode laser on enamel combined with sodium fluoride created reservoirs for minerals.

In an attempt to explain the mechanism of synergistic effect between fluoride and laser, ***Rodrigues et al., (2004)*** stated that when laser and fluoride are combined, it is possible to reduce laser energy density and fluoride levels; If this laser technology becomes available at a reasonable cost and the results can be applied in clinical practice, there will be a promising future for this laser in caries prevention. On the other hand, some authors believe that laser irradiation can increase bonding of fluoride to the tooth structure and lead to a remarkable increase in the fluoride content in enamel ***(Villalba-Moreno et al., 2007).***

Conclusion:-

The combination between laser and fluoride has a reparative effect on initial carious lesion in enamel. The application of fluoride in combination with laser improves the surface microhardness of the demineralized enamel.

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