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Influence of Er, Cr: YSGG and Diode Lasers on The Surface Roughness of Enamel at Fissure area: An in vitro Study.

Sara Abed Al Moneim Mohammed [1], Saher Sami Gasgoos [2]

[1] Ministry of Health/ Nineveh Health Directorate.

[2] Department of Pedodontics, Orthodontic and Preventive Dentistry, College of Dentistry, University of Mosul, Iraq.

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***Correspondence:**
E-mail:
sara.dep75@student.uomosul.edu.iq

Abstract

Aims: To assess and report the surface roughness incidence in fissure system of the dental enamel in human next Er, Cr: YSGG laser and Diode laser applications in order to examine anti-cariogenic impact and to compare the obtained results between the two laser types. **Materials and Methods:** Forty extracted impacted lower third molars teeth used in the experiment that should have an obvious occlusal fissure. Intact lower third molar were collected, which were free from caries .Teeth roots cut from crowns and crowns were divided bucco - lingually to two parts equally which were applied in 4 category included control group without any treatment, acid group only immersed in demineralizing solution, Diode laser group in which samples subjected to Diode laser (at wavelength 980nm, power 5 watt, mode P3, the time was 30 second) then immersed in demineralizing solution PH 4.4 for 96 hr., and Er, Cr: YSGG laser group in which samples subjected to Er, Cr: YSGG laser (wave length 2780nm, pulse energy20 Hz with pulse mode (H-mode), time 10 second) then immersed in demineralizing solution pH 4.4 for 96 hr. **Results:** both types of lasers resulted in a less surface roughness of enamel at fissure area as compared to the acid group, and Diode laser had better effect than Er, Cr: YSGG. The differences were statistically significant among the four groups at $p \leq 0.01$. **Conclusions:** Diode and Er, Cr: YSGG lasers improved the enamel surface roughness when compared to acid group.

الخلاصة

الأهداف: لتقييم وتعيين خشونة السطح التي تحدث بطبقة المينا للشقوق الموجودة على سطح الاطباق بعد استخدام ليزر الدايود و ليزر الإربيوم لفحص تأثيرهم كمقاومة للتسوس ومقارنة النتائج بين الليزرين. **المواد وطرائق العمل:** تم استخدام اربعون ضرس عقل سفلي واضحة الشقوق على سطح الاطباق. ضروس العقل التي جمعت كانت سليمة وخالية من التسوس. تم فصل الجذور عن التيجان وقُطعت التيجان الى نصفين من السطح الخدّي الى اللساني بالتساوي ثم وُزّعت عشوائيا بين اربع مجاميع، مجموعة السيطرة خالية من العلاج، مجموعة الحامض غُمرت بالحامض فقط (درجة حامضيته 4.4 لمدة 96 ساعة)، مجموعة ليزر الدايود التي عُرّضت فيها العينات للدايود ليزر (عند طول موجي 980 نانومتر وطاقة 5 واط ومدة التعرض 30 ثانية) وبعدها غُمرت في الحامض، ومجموعة الاربيوم ليزر عُرّضت فيها العينات للإربيوم ليزر (عند طول موجي 2780 نانومتر ونبض 20 هرتز لمدة 10 ثواني) ثم غُمرت في الحامض. **النتائج:** أنتج كلا النوعين من الليزر سطح خشونة بالمينا اقل من مجموعة الحامض، وكان تأثير الدايود ليزر افضل من الاربيوم. كانت الاختلافات بين المجاميع بدلالة احصائية عالية. **الاستنتاجات:** الدايود والإربيوم ليزر يُحسّنان خشونة السطح عند المقارنة مع مجموعة الحامض.

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INTRODUCTION

Dental caries is a multifactorial, food modulated, biofilm-mediated, non-communicable, dynamic disease lead to clear mineral loss of dental hard tissues.[1] Caries appears on the teeth just where plague is present, it is a demineralization activated by bacteria forming acids, and the amount of mineral loss is straight modified by both the activity and presence of the dental plaque.[2] Anatomical depth and morphological form for fissures and pits raise the incidence of dental caries. All experimental observation established that an increase in exposed of fissures and pits to caries occurrence than smooth surfaces since fissure anatomy and morphology helps dental biofilm growth and stagnation of food debris.

On the other hand it is more difficult to clean deep fissures and pits by the bristles of tooth brush and consequently increase retention of dental plaque and retention of diet fragment will be a very good shelter or habitat for dental caries bacteria.[3]

Preventative interventions against dental decay are powerfully suggested by the World Health Organization (WHO).[4] The use of sealant on enamel fissures and pits of molars is the most commonly application of traditional prophylactic interventions (TPIs) against dental decay [5] and high fluoride varnish or gel of topical management.[6] Laser might act as complementary or an alternative prophylactic treatment to traditional prophylactic interventions (TPIs) to development the prevention of dental decay.

In latest years, laser has been applied at sub-ablative levels for prevention objectives against dental caries, power sufficient to change enamel structure but can’t ablate the tissue. In the 1980s, laser light has been presented to be capable to change superficial dental enamel tissues structure. When the sub-ablative energy of laser light interacts with the enamel, it result in a superficial and rapid raise in heat from 100°C to 1600°C stimulating the alteration in structural tissue.[7] It’s essential not ablate the surface with laser irradiation, but must alter the morphology of enamel and physical properties (fusion, recrystallization and melting of enamel hydroxyapatite crystals) reducing permeability of enamel. Two clarifications of lasers for dental caries prophylactic are organic blocking theory and development of micro-spaces and micro-fissures in enamel of the lased tooth. Most scientist believe water loss and carbonate decomposition are accountable for dental caries prophylactic.[8]

This study was conducted to assess the surface roughness in fissure system of the dental enamel in human next Er,Cr:YSGG laser and Diode laser applications in order to examine anti-cariogenic impact and to compare the obtained results between the two laser types.

MATERIALS AND METHODS

Teeth Sample Collection and Criteria: Forty extracted impacted lower third molars teeth from individuals at age range between 20-25 years used in the experiment that should have an obvious occlusal fissure. Intact lower third molar were collected, which were free from caries, no enamel hypoplasia or developmental anomalies no cracks, wears or fractures.

The Experimental Design of the Study: The total number of teeth sample in current study was (80) teeth samples. The samples were randomly distributed into 4 tested groups exposed to various type of treatment. Group 1: the included samples were not received any type of treatment, Group 2: the included samples were submerged in a demineralization solution, Group 3: the included samples were received Diode laser prior to immersion in the demineralization solution, finally Group 4: the samples were received Er,Cr:YSGG laser irradiation before immersion in the demineralization solution.

Sample preparation: All soft tissues were removed by scaling and teeth were polished with super-fine fluoride free pumice using rubber cup. Teeth were stored in thymol solution (0.1%, pH 7.0) to avoid bacterial growth and were kept in a refrigerator at 4 °C till use.[9] Utilizing diamond low speed disc for cutting roots from crowns and then the crowns were divided bucco-lingually in to two equal parts which were applied in 4 tested groups.

Diode Laser Application: Teeth samples in group 3 were exposed to diode laser at wavelength 980nm and the power was 5 watts,[10] mode P3, the time was 30 second and the tips used were e 4 (Epic x 4 mm length, 0.4 mm diameter).

Er,Cr:YSGG Laser Application: Laser parameter applied in the application wave length 2780 nm, pulse energy 20 Hz with pulse mode (H-mode), time 10 seconds. The power Er, Cr: YSGG laser applied in the current study was (0.75 W). This power was established on prior studies which likened other Er,Cr:YSGG power values or with other types of laser. Results discovered the best effects concerning acid resistance enhancement in 0.75 W power was gave.[11,12] Water and air flow were set to (40%, 60%) respectively.[13] MZ6 tips with (6mm) length and (0.6mm) diameter were used for sample irradiation and Irradiation distance 1mm from enamel surface.

Sample Mounting in Acrylic Ring: Plastic ring were cut and prepared so that, the upper and lower sides were flat and parallel to each other (12 mm diameter×14 mm depth). Embedding the tooth in epoxy resin with cut side expose then polished one by one with a fine grit silicon carbide papers (600-, 800-, and 2400 grit). Lastly, all samples were washed with deionized water and kept till immersion in demineralized solution.

Immersion in Demineralized Solution: All samples except control group were immersed in demineralizing solution for 96 hr. (4 days) at 37 °C which was collected by (2.2 mM) KH_2PO_4, (2.2 mM) $CaCl_2$, and acetic acid (0.05 M), with pH (4.4) modify by (1 M) KOH.[14] Then all samples were picked up from the solution after 96 hr. and washed with deionized water. **Surface Roughness Test:** The surface roughness of the enamel surfaces samples was analyzed by using a profile projector with magnification of 50 X which is a commonly accepted method to assess surface textures. It is a common method to analyze surface configuration and comprises a non-invasive approach. Moreover, in this system the whole roughness is quantified by a metric average value which permits a statistical evaluation.[15] . The test was done at the Technical institute/ University of Mosul.

A partition of typical distance was gotten from the average line on the roughness diagram. In the Y direction, the distance between the uppermost peak (Rp) and lowermost valley (Rv) of the tested line was quantified which is (Ry). The quantity was calculated in micrometer (μm).[16]

Statistical Analysis: The data were analyzed utilizing SPSS program which involved descriptive statistics which included mean surface roughness and standard deviation for each group, Independent t-test Sample: This test was utilized to evaluate the surface roughness between specimen groups of Er,Cr:YSGG laser group and diode laser group, ANOVA test (One Way Analyses of Variance) and Duncan's Multiple Range Test were employed to observe the significant variances between the tested samples. The statistical results were regard as significant at $p \leq 0.01$.

RESULTS

According to the obtained measurements of this study, Table (1) showed the descriptive statistics including means, number of tested groups, standard deviations and range. Based on the measurement for tested groups, Acid group had the highest surface roughness mean value when compared with other groups. The mean values of enamel surface roughness in fissures are compared by (ANOVA) test one-way analysis of variance, and the results revealed that there were a highly statistically significant differences within and in between groups at $p \leq 0.01$ as shown in table (2).

Table (1): Descriptive statistics of surface roughness measurements among tested groups.

Surface Roughness				
Groups	**Mean**	**N**	**Std. Deviation**	**Range**
Control	0.509	20	0.03712	0.13
Acid	1.12	20	0.14871	0.47
Diode	0.6815	20	0.02084	0.07
Er,Cr:YSGG	0.865	20	0.02685	0.1
Total	0.7939	80	0.24058	0.91

Table (2): ANOVA test of surface roughness between tested groups at $p \leq 0.01$.

ANOVA Test					
Roughness	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	4.104	3	1.368	221.993	
Within Groups	0.468	76	0.006		0.000
Total	4.572	79			

Duncan's Multiple Range test shows that the mean surface roughness for Control group, Acid group, Er,Cr:YSGG laser group and Diode laser group are significantly different from each other at $p \leq 0.01$. Acid group had mean surface roughness significantly higher (1.1200) than other groups, Er,Cr:YSGG laser group had mean roughness of enamel surface (0.8650), Diode laser group had mean surface roughness (0.6815) while control group had lesser mean on surface roughness (0.5090) as shown in figure (1). The analysis of variance of t-test used for Er,Cr:YSGG laser group and diode laser group. Er,Cr:YSGG group show more enamel surface roughness in fissures than diode laser group at ($p \leq 0.01$) as shown in table (3). So, Diode laser application resulted in better improvement in surface roughness than Er,Cr:YSGG laser.

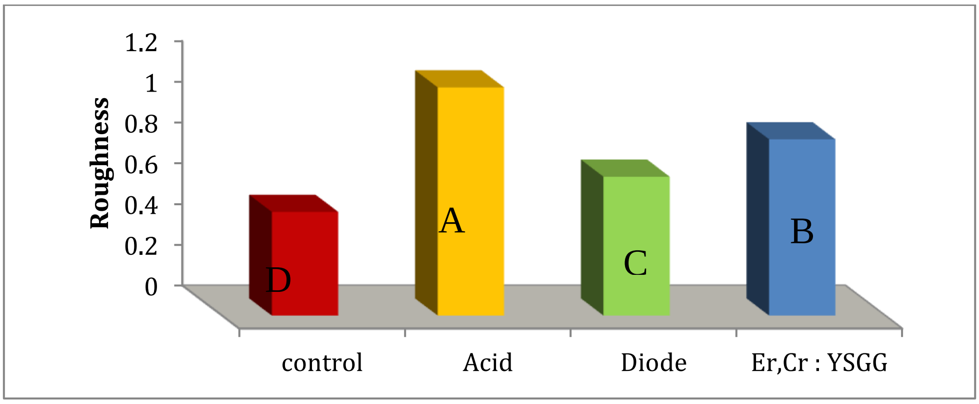

Figure (1): Duncan's Multiple Range test of surface roughness measurements for control group, acid group, diode laser group and Er,Cr:YSGG laser group.

Table (3): The t-test analysis for determining the significant difference in surface roughness between Er,Cr :YSGG laser group and diode laser group.

t-test						
Roughness	**N**	**Mean**	**t-value**	**sig**	**Std. Deviation**	**Std. Error Mean**
Diode	20	0.6815	-24.141-	0.000	0.02084	0.00466
Er,Cr:YSGG	20	0.865		0.000	0.02685	0.006

** highly statistically significant at $p \leq 0.01$.

DISCUSSION

According to the result of current study there was increase in enamel surface roughness after laser exposure Er,Cr:YSGG about (0.86) µm, diode about (0.68) µm as compared to control group about (0.5) µm, although the surface roughness of the acid group in this study about (1.12) µm but laser increase surface roughness when compared to control group, this observation agree with Ersahan and Alakus, (2016)[17] which established that when laser is irradiated on the tooth, the energy is absorbed and altered to heat and water in the tooth boils leading to high-pressure steam, and the smooth tooth surface change by the explosive vaporization of water into usually flaky with irregularly serrated and micro-fissured structure, and one which is usually free from melting and carbonization. In the other study, morphological alterations like as enamel prisms cone-like shape and a raise surface roughness were also detected next laser apply.[18]

Ganss *et al*., (2005)[19] used a profilometric method to investigate the result of acid on the dental tissue. The amount of the roughness, height, and lowness of the surface of teeth was measured with a diamond probe.

Tagomori *et al.*, (1995)[20] observed that the enamel surfaces irradiated reliably display surface roughness higher than untreated ones. According to Sawan *et al*., (2015)[21] stated the laser-ablated surfaces show the formation of craters, and have appropriate enamel roughness.

The Er,Cr:YSGG laser cutting mechanism is called "thermos-mechanical process" in which emitted laser pulsed-wave is directly absorbed by the water in the hydroxyapatite of enamel and dentine and produced the vaporization of the heated water and other hydrated organic components. Vaporization effects in increased internal pressure within the target tissues that in conclusion caused instantaneous micro-explosions that destroy the inorganic components before the melting point of tooth tissue and leads to ejection of micro-fragments.[22]

A previous study done by Sun *et al*., (2015).[23] found that specimen treated with the lesser variety of power (0-4 W) of Er,Cr:YSGG laser, presented with raised enamel surface roughness. In other study, Issar *et al*., (2016)[24] concluded that the irradiated of enamel surfaces with Er,Cr:YSGG laser showed elimination of smear layer and micro-irregularities.

No studies were found on enamel roughness after diode laser radiation although Ruchele *et al.*, (2017)[25] in their study showed that diode laser impacts in enamel and the morphology of the enamel was alter and, so, its roughness but used the pigmented 5% sodium fluoride varnish which generating photo-thermal effect because this varnish operated as a photo-absorber for the diode laser photons,. Based on current study enamel surface roughness after Er,Cr:YSGG laser irradiation more than after diode laser radiation.

CONCLUSION

The laser improves the enamel surface roughness when compared to acid group, and roughness of a lased enamel surface is lower following Diode laser treatment when compared to Er,Cr;YSGG laser treatment.

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