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Influence of Er:Cr;YSGG laser Desensitization on SBS of resin cement to dentin

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Abstract

Background: Crown preparation of vital teeth involve the removal of a sound tooth structure, and when enamel removed this lead to exposed dentin with an increase in the number of open dentinal tubules also the diameter of dentinal tubules will increase, furthermore lead to increase movement of fluids inside the tubules all that causes post preparation sensitivity. **The aim** of this study is to evaluate the effect of desensitizing by Er:Cr:YSGG laser on shear bond strength of prepared tooth and resin cement. **Materials and methods:** Thirty sound maxillary premolars, grouped into three groups(n=10). Group A is the control group, group B irradiated by Er:Cr:YSGG laser with (0.25 W, 20 Hz, 10%water and air), group C irradiated by Er:Cr:YSGG laser with (0.5 W, 20 Hz, 10% water and air). **Results:** SEM examination showed complete occlusion of opened dentinal tubules after laser irradiation of both groups that irradiated with laser. Statistical analysis showed significant increase in surface roughness in group B and C. SBS was significantly increase in group B with no significant increase in group C. **Conclusion:** Er:Cr:YSGG laser can occlude open dentinal tubules without and adverse effect on the retention of the restoration, on the contrary it increase bonding strength. And this increasing was significant in group B with (0.25W, 20 Hz, 10 % water and air). **suggestion:** so the parameters used in group B (0.25 W, 20Hz, 10 % water and air) is recommended for desensitizing prepared tooth and induce enhancement to the bonding strength of resin to tooth surface.

Introduction

Dentinal hypersensitivity is very common dental issue, characterized by a quick intense pain reaction of exposed dentin anytime it comes into contact with external stimuli, such as thermal, tactile, evaporative, and chemical. When dentin hypersensitivity develops, the patient becomes so irritated that they refuse to eat cold foods or brush the affected tooth. (Arua, Fadare, & Adamu, 2021). Dentin hypersensitivity is defined by the most widely accepted mechanism, which describe by Brännström, he explained it based on the hydrodynamic theory. Dentin hypersensitivity, according to this theory, is caused by fast fluid movement in the dentin tubules as a result of external stimuli. Nerve endings (A- and A-fibers) at the dentin-pulp interface may be activated by stimulus-induced fluid flow; the excited nerve terminations are referred to as mechanoreceptors. Depending on the stimulation, the abrupt migration of dentin fluids may be directed outward or inward. Outward flow is produced by cooling, drying, evaporation, and hypertonic solutions, which causes more discomfort than inward flow caused by heat application. (Brannstrom, 1963). Tubules in the dentin render the tissue porous, especially when the outer protective layer represent by the enamel and cementum is removed. Many dental procedures require the removal of the cementum or enamel layer to reveal the dentin, such as root planning, cavity preparation, and crown preparation. Hypersensitivity of the vital teeth post-cementation due to ingress of luting cement into the opened dentinal tubules this will affect the hydrostatic pressure by moving or displacing equal amount of dentinal fluid inside the tubules (Mausner, Goldstein, & Georgescu, 1996). Several techniques have been tested to date to eliminate such patient discomforts (calcium hydroxide, cavity varnishes, topical fluorides, fluoride iontophoresis, strontium chloride, and potassium nitrate dentifrices) (Sethi & Indurkar, 2015). The majority of therapies have attempted to block exposed dentin tubules, but none have proven to be consistently successful or long-lasting (Romano, Aranha, da Silveira, Baldochi, & de Paula Eduardo, 2011). For the treatment of dentin hypersensitivity, laser therapy was introduced as an alternative. Before crown cementation, desensitizing laser treatment has been found to occlude exposed dentinal tubules and reduce hypersensitivity for longer lengths of time than any other desensitizing agent, and this practice is gaining appeal around the world (Atay, Kara, Kara, Çal, & Usumez, 2017). However, due to the obvious significance in physical and mechanical characteristics of resin cements, the effect of laser desensitizing treatment on crown retention is important (Huang et al., 2020). Er:Cr;YSGG laser which is absorbed by water of the dentin, converting water to steam by heating, then the steam expand and since this reaction is explosive in nature (microexplosion), this microexplosion causing dentin debris to occluded or tightening the dentinal tubules this will prevent emerging of cement to the dentinal tubules and prevent post cementation hypersensitivity (Kumar et al., 2015) . Er:Cr:YSGG aser had been used for treatment of dentinal hypersensitivity successfully , but its effect on surface roughness or bonding strength is still not clear. So this study aimed to study the effect of tooth desensitization on shear bond strength of resin cement to dentin surface.

Material and Methods

1. Sample collection and preparation

For orthodontic purpose, freshly extracted human maxillary premolars (total 63) with an age average of (16-35) years. These teeth washed in a running water for debris removal. All samples were scaling and root planning, to eliminate any source of infection and to handle with clean samples then preserved in 1% thymole solution. Teeth were molded in an acrylic cylindrical mold up to the cemento-emamel junction.

With the use of a dental surveyor, the teeth were held in the zero plane. The occlusal side of the teeth cut with a diamond disc as shown in figure (1). Then the prepared occlusal side of the samples polished was with non-fluoride pumice for 15 seconds, washed in an ultrasonic cleaner for 15 min.

Finally, teeth were divided randomly into three groups; group A, which is the control group. Groups B, and C, both treated by laser.

2. Laser application

Er:Cr;YSGG 2780 nm Dental laser (WaterLase iPlus .USA) was used to irradiate groups B and C . Standardized irradiation was performed with the use of CNC machine, with scanning speed 10 mm/sec figure (2).

Figure (1) Teeth preparation set-up with the dental surveyor, diamond disc for cutting.

- Group (A) is the control group.
- Group (B) Er: Cr; YSGG laser with (0.25 W, 20 Hz, 10% water and air.
- Group (C) Er: Cr; YSGG Laser with (0.5 W, 20 Hz, 10% water and air.

After many trials to determine the most suitable parameters that induced morphological changes to dentin surface without any carbonization or cracks two parameters selected. Laser light was delivered perpendicular to prepared occlusal surface of the tooth in non-contact mode (2mm away from the tooth surface). For group B laser parameters were (0.25 W, 20 Hz, 10% water and air), while in group C (0.5 W, 20Hz, 10% water and air).

3. SEM Examination

The effect of the laser on dentinal tubules was assessed using a scanning electronic microscope (SEM) (INSPECT F50, USA).

Figure (2) A) Er:Cr;YSGG laser, B) CNC machine.

4. Measurement of Temperature

The temperature rise during laser application was measured using a thermometer on 5 samples from each of the laser-treated groups (Groups B and C) (Amprobe TMD-56). The teeth were prepared with a Sx pro-taper file to provide a passage for the thermocouple wire (with a temperature range of (-200°C to 1372°C) and a head diameter of 0.8 mm) to be inserted from the apical opening of the root to the roof of the pulp chamber, and then fixed with thermal paste. The samples were placed in a water bath at 37°C for testing, with only the root immersed in the water.

5. Roughness Assessment

Roughness was evaluated before and after laser therapy on all samples using a profilemeter (surface roughness tester SRT-6210, China). Surface roughness for each sample was the mean of three reading was determined at three different places on the dentin surface.

6. Cementation of Zirconia disc

The first stage is to make 3 mm diameter (which represent the bonding area) and 5 mm height zirconia cylinders (KATANATM Zirconia, Ht, Japan). They were made using CAD/CAM technology. Cleaned with ultrasonic cleaner before use. Self-adhesive resin cement (Breeze, Pentron Clinical, CA92867, USA) was used for cementation; it was auto-mixed with disposable mixing tips included in the cement kit and applied directly to the tooth surface. To ensure appropriate light curing, a silicon mold was constructed with a central hole of 3 mm in diameter and a 3 mm height split from the internal surface into 1 mm for cement and 2 mm for the zirconia disc. A weight of 2 Kg was employed during the cement setting with the use of a dental surveyor (Beuer, Schweiger, & Edelhoff, 2008) to avoid any air bubbles and ensure adequate cementation. The load was removed after 4 minutes of curing. To ensure full curing, the samples were left on the table for one hour. After that, the cemented samples were placed in a water bath at 37°C for 24 hours before being tested for Shear Bond Strength.

7. Shear Bond Strength measurement

Universal testing machine (ARYEE, WDW-50, 50 KN. China). was used to measure the shear bond strength. The tooth was positioned horizontally, and a stainless steel chiseled-shaped blade was used to cut through the tooth-resin cement contact until total separation was achieved.

8. Results

The results of the laser effect on dentinal tubules, temperature, roughness measurements, and shear bond strength examination. Statistical analysis using descriptive statistics, Paired T test, Independent samples t-test, and one-way ANOVA using (SPSS 24), are lasted below.

8.1. Temperature Measurement

In table (1) mean of temperature rise during laser application was maintained. The maximum rise in temperature in group B (Er:Cr;YSGG irradiation with 0.25 W, 20 Hz, 10% water and air) was 1.1. While in group C (Er:Cr;YSGG irradiation with 0.5 W, 20 Hz, 10% water and air) was 1.4.

Table (1) Mean and Standard Deviation of temperature change.

Groups	Mean	Standard deviation (SD)
Group B	0.9	0.158
Group C	1.24	0.114

8.2. SEM Evaluation

Examination of dentin surface was done by Scanning Electronic Microscope (SEM) (INSPECT F50, USA) as in figure (3) SEM evaluation showed open dentinal tubules in group A, which is the control group.

SEM of group B laser treated dentin shows complete occlusion of dentinal tubules, with no sign of carbonization or cracks, as shown in figure (4)

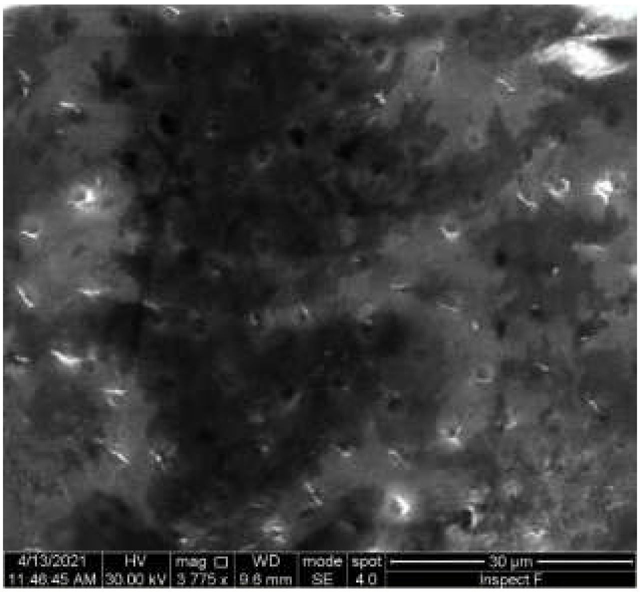

Figure (3) SEM evaluation of group A with open dentinal tubules

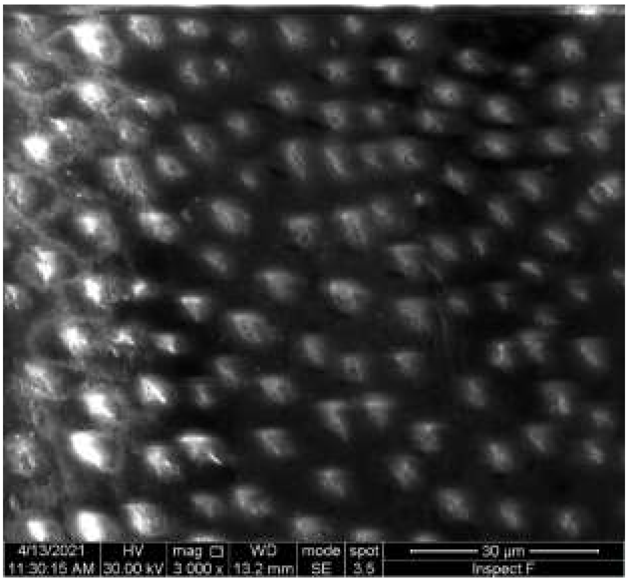

Figure (4) SEM image of group B

In group C laser treated with 0.5 W shows also complete occlusion of dentinal tubules as in figure (5)

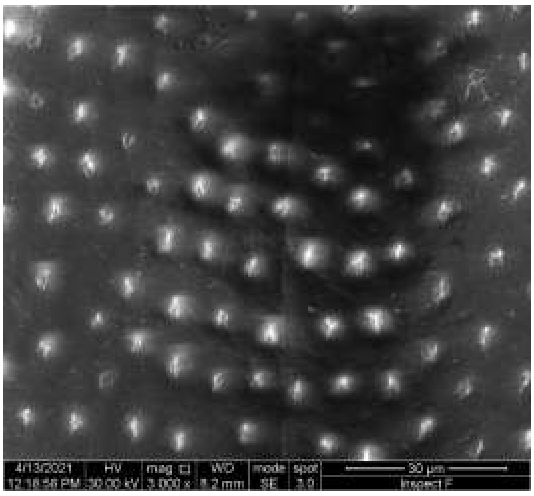

Figure (5) SEM Image of group C

Descriptive statistical analysis of each laser treated groups, before and after laser treatment. With higher increase in roughness in group B after laser irradiation. Statistical analysis using Paired T test, to determine significance in difference in roughness before and after laser irradiation, as maintained in table (2). The result showed that both groups have significant difference in roughness

8.3. Roughness assessment

Table (2) Descriptive statistical analysis, along with Paired T test of Roughness changes

Groups		Before	After
	Effect size	10.916 large	
Group B 0.25 W-ER:CR:YSGG Laser	Minimum	0.632	1.608
	Maximum	0.905	1.930
	Mean	0.765	1.768
	SD	0.088	0.095
	SE	0.028	0.030
	% of change	131.111	
	Paired T test	38.972	
	P value	0.00000 Sig.	
	Effect size	12.324 large	
Group C 0.5 W-ER:CR:YSGG Laser	Minimum	0.769	0.879
	Maximum	0.932	1.127
	Mean	0.827	0.974
	SD	0.055	0.071
	SE	0.017	0.023
	% of change	17.7751	
	Paired T test	6.233	
	P value	0.00015 Sig.	
	Effect size	1.971 large	

3.4. Shear Bond Strength (SBS)

Descriptive statistical analysis of SBS of all groups shown in table (3). The results showed higher mean of bond strength in group B than other groups. And the lowest mean of bonding strength in the control group.

Table (3) The Mean, and Standard Deviation of all groups for SBS in (MPa).

Groups	Mean	±SD	±SE	Minimum	Maximum
Group A (Control Group)	13.1990	1.08611	.34346	12.03	14.80
Group B 0.25 W-ER:CR:YSGG Laser	16.3300	2.18177	.68994	12.70	19.80
Group C 0.5 W-ER:CR:YSGG Laser	13.9800	1.46652	.46375	11.30	16.40

To determine difference between all the groups One-way ANOVA test was performed. The results showed significant difference between all groups as shown in table (4).

Table (4) One-way ANOVA test

ANOVA					
	Sum of Squares	df	Mean Square	F	P value
Between Groups	53.119	2	26.559	9.848	0.001 Sig.
Within Groups	72.814	27	2.697		
Total	125.932	29			

Statistical analysis using Tukey HSD, to determined significance in SBS in all groups, as showed in table (5). Results showed that bond strength in group B is significantly higher than group C and group A which is the control group. While group C is not significantly higher than the control group.

Table (3-5): Tukey HSD test of shear bond strength of all groups.

Dependent Variable: SBS				
Tukey HSD				
(I) Groups	(J) Groups	Mean Difference (I-J)	p value	
Group A (Control group)	Group B	-3.13100-*	.001	Sig.
	Group C	-.78100-	.544	NS.
Group B (0.25 W-ER:CR:YSGG Laser)	Group A	3.13100*	.001	Sig.
	Group C	2.35000*	0.009	Sig.
Group C 0.5 W-ER:CR:YSGG Laser	Group A	.78100	0.544	NS
	Group B	-2.35000-*	.009	Sig

9. Discussion

Crown preparation is an invasive treatment method necessitated the removal of tooth structure, sound tooth structure, to function as an abutment for the bridge's attachment. When tooth structure is removed, open dentinal tubules result, that are susceptible to hypersensitivity (Pilo, Harel, Nissan, & Levartovsky, 2016). The best treatment for this post-operative complication is occluding dentinal tubules without impacting prosthesis retention(Ayer, 2018). In this study two parameters used for treatment of dentinal hypersensitivity, group B (0.25 W, 20 Hz, 10% water and air), and group C (0.5 W, 20 Hz, 10% water and air). Both of the experimental groups as showed by the SEM examination, the result was also complete occluding of dentinal tubules. with no carbonization or cracks. Another trial was done by Klabd et al., and used Er:Cr:YSGG for treatment of dentinal hypersensitivity and get complete occluding of dentinal tubules, which support the results obtained from this study (Habdan, Awdah, Meshari, Mokeem, & Saqat, 2017). The closure of dentinal tubules as seen in the SEM images, could be explained by the action of Er: Cr: YSGG Laser, which interacts with dentin, absorbed by water of the dentin, converting water to steam by heating, then the steam expand and since this reaction is explosive in nature (microexplosion), this microexplosion causing dentin debris to occluded or tightening the dentinal tubules (Stübinger, Klämpfl, Schmidt, & Zeilhofer, 2020). The advantage of this phenomes is preventing environmental factors effecting dentinal tubules, as well as prevent emerging of cement to the dentinal tubules and prevent post cementation hypersensitivity(Abdollahi & Jalalian, 2019). The influence of the laser on temperature indicated that, it was below the proposed temperature rise which cause pulpal necrosis (5.6) (van Gemert & Niemz, 2013) in both experimental groups. That’s mean that laser effect on the dentinal tubules was superficial and heat was not to the pulp, supporting the safety of this technique in the treatment of dentinal hypersensitivity due to tooth preparation. This minimum thermal effect of these parameters due to pulse duration is very short, and shorten the heat generation time that gives the tissue enough time to cool down (Convissar, 2015). Also the use of 10% water and air helped effectively in cooling during laser application. Laser radiation to dentin induced significant increase in roughness in in both lasers treated groups (B, and C). This refers to the Er:Cr:YSGG laser interaction with water and hydroxyapatite of the dentin, that interaction is explosive in nature, induce debris that produced from lasing process, to accumulate on the dentin surface, and produces a roughened surface. As noticed from the obtained results that group B with lower energy induce higher roughness, and this refer to melting produced by group C laser treated with 0.5 W. As Er: Cr: YSGG laser induce melting to peritubular dentin (Gholami, Fekrazad, Esmaiel-Nejad, & Kalhori, 2011). An increase in roughness of dentin will improve bonding of adhesive materials to dentin by increasing shear bond strength (Hossain et al., 2001). SBS was significantly higher in group B than group C. this may attributed to higher roughness obtained from Group B than group C. A study found marginal increase in SBS of resin cement to dentin that desensitized with 0.5 W (Kumar et al., 2015).

10. Conclusion

According to the result we can concludes the following:

1.Er:Cr;YSGG laser is an effective treatment approach for dentinal hypersensitivity with complete occluding of dentinal tubules without any side effects like carbonization, cracks, or inducing damage to the pulp tissue.

2. An increase in dentin surface roughness due to laser irradiation induces an increase in shear bond strength to resin cement.

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تأثير ازاله تحسس السنان بليزر الاربيوم كروميوم على قوه رابطه القص بين عاج السن والسمنت الراتنجي

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الخلاصة: يتضمن إعداد تاج الأسنان الحيوية إزالة جزء من بنية الأسنان السليمة، وعندما تتم إزالة المينا يؤدي ذلك إلى ان يكون عاج الاسنان مكشوف مع زيادة في عدد أنابيب الأسنان المفتوحة أيضا سيزداد قطر أنابيب الأسنان، مما يؤدي إلى زيادة حركة السوائل داخل الأنابيب كل ذلك يسبب حساسية ما بعد التحضير.الهدف من هذه الدراسة هو تقييم تأثير إزالة الحساسية بواسطة ليزرالاربيوم كروميوم على قوة رابطة القص للأسنان الجاهزة والاسمنت الراتنجي. تم تحضير ثلاثون سن من اسنان الفك العلوي, وتقسيمها الى ثلاث مجاميع. المجموعه أ هي المجموعه الضابطه والمجموعه ب مشععه بليزر الاربيوم كروميوم بقوه 0.25 واط، 20 هرتز، 10% ماء وهواء. المجموعه ج كذلك مشععه بليزر اربيوم كروميوم بقوه 0.5 واط, 20 هرتز، 10% ماء وهواء. اظهر فحص المايكروسكوب الماسح الالكتروني انسداد تام في انابيب الاسنان المفتوحه بعد التشعيع بالليزر لكلا المجموعتين. اظهر التحليل الاحصائي زياده كبيره في خشونه السطح في المجموعتين ب وج. وكانت الزياد في قوه رابطه القص للمجموعه ب كبيره وملحوظه وكانت الزياده غير ملحوظه في المجموعه ج . نستنتج من ذلك ان ليزر الاربيوم كروميوم يقوم بغلق انابيب الاسنان المفتوحه ولايؤثر ذلك على قوه الربط بين الاسنان ومواد الحشوات بل على العكس فالمجموعه ب تظهر زياده ملحوظه في الترابط ويمكن العمل بها بعد تحضير الاسنان لتلافي الاصابه بتحسس الاسنان