



## Er,Cr:YSGG Laser-Assisted Removal of Ceramic Veneers Cemented with G-Cem Resin Cement: (An in vitro study)

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### Abstract

**Aims:** To evaluate the efficiency of Er,Cr: YSGG laser in debonding of veneers made of lithium disilicate (E-max<sup>®</sup>) as measured with the shear bond strength(SBS), determine the impact of two laser powers on the SBS required to debond veneers, and finally determining the mode of failure for each group. **Materials and methods:** Thirty ceramic discs (1mm in thickness and 5mm in diameter) were prepared according to the manufacturer's instructions. The facial surfaces of enamel for thirty bovine teeth were prepared smooth and the discs cemented onto these prepared surfaces by using G-Cem<sup>TM</sup> veneer light cure adhesive cement. Specimens were stored in distilled water for 48hours, after which they were divided randomly into three equal groups (n=10) according to the laser power used as follows: Cont.: Control group that wasn't subjected to laser irradiation; L3: Group irradiated at 3 watt (60 sec.); L5: Group irradiated at 5 watt (60 sec.). SBS was measured by "Instron universal testing machine" and the mode of failure was assessed using stereomicroscope. **Results:** Both laser irradiated groups showed significant difference in reducing the SBS (p=.000), some of discs debonded during laser irradiation. However, there was no significant difference between the two laser powers used (p=.418). **Conclusions:** Er, Cr: YSGG could be a safe, effective, fast, and harmless method for reducing SBS of bonded E-max<sup>®</sup> laminate veneers, without affecting the tooth and the veneer itself. Since there was no significant difference between the two laser powers used, it is advocated to use 3 watts.

### الخلاصة

**الاهداف:** تهدف الدراسة الى تقييم كفاءة ليزر Er Cr: YSGG في فك ارتباط القشور الخزفية المصنوعة من مادة السيراميك lithium disilicate (E-max<sup>®</sup>) مقاسة بقوة ربط القص، وكذلك تحديد تأثير قوتين من الليزر (3 و 5 واط) على قوة القص المطلوبة لفك ارتباط لقشور الخزفية، واخيرا فحص طبيعة الفشل. **المواد وطرق العمل:** تم تحضير ثلاثون قرص من مادة السيراميك (ارتفاع 1 ملم وقطر 5 ملم) مختبريا حسب تعليمات الشركة المصنعة. تم تحضير السطح الشفوي لثلاثين سن بقرية وجعلها مستوية وتم لصق الاقراص على هذه الاسطح باستخدام لاصق G-Cem<sup>TM</sup> الراتنجي. تم خزن النماذج في الماء المقطر لمدة 48 ساعة، قسمت بعدها بشكل عشوائي الى ثلاثة مجاميع متساوية (عشر عينات/مجموعة) وكالاتي: مجموعة السيطرة والتي لم يتم تعريضها لاشعاع الليزر، ومجموعتي الليزر حيث تم تعريضهما لاشعاع الليزر بقوة (3 واط و 5 واط) على التوالي ولمدة 60 ثانية. تم قياس قوة ربط القص باستخدام جهاز الفحص العالمي وفحص طبيعة الفشل باستخدام الميكروسكوب. **النتائج:** أظهرت مجموعتي الليزر (3 واط و 5 واط) فروقات ذات دلالة معنوية في خفض قوة ربط القص اللازمة لفك ارتباط القشور الخزفية مقارنة مع مجموعة السيطرة. لم يكن هناك فروقات ذات دلالة معنوية بين مجموعتي الليزر. **الاستنتاجات:** ليزر Er Cr: YSGG يمكن ان يكون طريقة فعالة، سريعة وامنة وبدون اذى لازالة القشور الخزفية دون التأثير عليها او على الاسنان. وحيث انه لم تكن هناك فروقات معنوية بين قوتي الليزر (3 و 5 واط)، لذا ننصح باستخدام قوة 3 واط.

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## INTRODUCTION

Ceramic veneer can be well-defined as very thin porcelain or all ceramic facing used to develop anterior aesthetic <sup>(1)</sup>. Porcelain materials have attracted attention since the 1980s when enamel was etched, and the porcelain surface was used to develop the bonding<sup>(2)</sup>. Like any other dental restoration, laminate veneers require replacement for variable intervals due to numerous causes such as caries, marginal leakage, chipped or fractured ceramic, periodontal problems, sensitivity, discoloration, and malposition during cementation<sup>(3,4)</sup>. The traditional method of removing veneers by using high-speed hand piece with a diamond bur may lead to damage to the restorations and harmful effects to the underlying tooth structures due to high bond strength and lack of contrast between the tooth, resin cement and restoration, as all of them have almost the same color, making it difficult for the dentist to distinguish between them. In addition, this method is time consuming, and painful for patients <sup>(5,6)</sup>. Among these drawbacks, the harmful effect on tooth structure is the most important issue <sup>(7)</sup>.

The use of lasers could eliminate most of the problems of debonding that are associated with the traditional methods <sup>(8)</sup>. The laser was suggested as an alternative method for debonding of all -ceramic fixed

Prostheses <sup>(9-11)</sup>. Lasers such as Er, Cr:YSGG can be used to remove undesirable or failed veneers <sup>(12)</sup>. The use of a laser to remove veneers to enhance the patient's comfort and reduces the time needed at chair-side and costs for the patient and laboratory <sup>(13)</sup>. It was shown that the detachment may occur at the connection of the silane and the adhesive agent; thus, underlying tooth does not suffer any trauma during this procedure <sup>(14)</sup>. In addition, lasers do not have a chemical effect on the ceramic materials<sup>(15,16)</sup>. Laser energy passes through the porcelain materials and is absorbed by water molecules and residual monomers in the adhesive cements, resulting in debonding or decreased SBS of laminate veneers <sup>(17)</sup>. Therefore, the aim of this study was to evaluate the efficacy of an Er,Cr:YSGG laser in the debonding of veneers made of lithium disilicate (E-max<sup>®</sup>), bonded with G-Cem<sup>™</sup> light cure luting agent as measured with the SBS. The impact of two laser powers (3 and 5 W) on the SBS required debonding veneers and finally studying the mode of failure. The first null hypothesis to be tested was that irradiation with Er,Cr: YSGG laser would not affect the SBS of the bonded veneers. The second null hypothesis was that different laser powers had no impact on the reduction of SBS.

## MATERIALS AND METHODS

### 1. Specimen's collection and preparation

The study was permitted by Research Ethics Committee board (University of Mosul, College of Dentistry, REC reference no. (UoM. Dent/ A.L.25/21).

Freshly extracted bovine mandibular incisors (n=30) obtained from a local abattoir from (2-3) years old were used as an acceptable substitute for human enamel<sup>(18)</sup>. Freshly extracted teeth were selected, with no crown fractures, enamel defects or caries<sup>(16)</sup>. To evaluate that the crown is with no cracks, the teeth were visually examined with light transillumination, teeth were cleaned from any attached soft tissues then scaled by using hand scaler and polished with fluoride-free pumice (Bilkim LTD/Turkey)<sup>(19)</sup>. Crowns were cut at the cemento-enamel junction with a carbide disk, the root parts were discarded and the pulp tissues in the crown part were removed using barbed broaches, then the canal space was cleaned with normal saline and dried<sup>(20)</sup>. The teeth were stored in distilled water at room temperature until further processing, not more than one week<sup>(21)</sup>.

Each specimen was placed in a cylinder plastic tube of 2.5 cm in diameter and 2.75 cm in height. Autopolymerizable cold cure resin (Veracril Cold Curing Dental Polymer, New Static, Antioquia-Colombia) cold cure epoxy resin was mixed according to the manufacture instructions and the specimens were embedded in acrylic resin (Figure 1), such that the facial surfaces of the enamel were located parallel to the basal area of the cylinder cast<sup>(22)</sup>. After the completion of polymerization, the facial surface of the teeth was abraded with abrasive discs to make a flat surface within enamel of 8mm in diameter in the middle of the middle third of the labial aspect and smoothed under running water by using 200,400, and 600 grit silicon carbide papers consecutively (English Abrasives, Holland) to obtain a standardized flat surface for bonding procedures, each carbide paper was used, approximately for 20 second. Then specimens were immersed in the dental ultrasonic bath for 3 minutes to remove any abrasive grain present in the specimen<sup>(23)</sup>. The specimens were stored in distilled water at room temperature which was changed weekly to avoid bacterial contamination<sup>(19)</sup>.



**Figure (1):** Bovine tooth specimen embedded in acrylic mold

## 2. Ceramic discs fabrication

Ceramic materials used in the study are lithium disilcate (IPS E-max<sup>®</sup> press, Ivoclar Vivadent, Schaan, Liechtenstein) shade A2 LT (low translucency). Thirty discs of 1±

0.05mm in thickness and  $5 \pm 0.02$  mm in diameter were prepared according to manufacturer instructions, using heat pressing technique. The discs dimensions were checked using a digital caliper (Figure 2).



**Figure (2):** A: Ingot of E-max press<sup>®</sup>; B: Measuring the thickness of the ceramic discs using digital caliper, C: Measuring the diameter of the ceramic disc.

## 3. Cementation:

### 3.1. Ceramic surface preparation:

The internal surfaces of the ceramic discs were etched by the application of IPS Ceramic Etching Gel (4.5% hydrofluoric acid) (Ivoclar, Vivadent) for 30 s for lithium disilcate discs (24). Then, washing thoroughly with water (20 sec) and ultrasonic cleaning in distilled water for 5 min (24) and dried with oil-free air. Monobond Plus silane (Ivoclar, Vivadent, Schaan, Liechtenstein) was then applied to the internal surfaces of the discs for 1 minute before bonding and allowed to air dry (20).

### 3.2. Conditioning of teeth surfaces

The prepared surfaces of the teeth were dried, etched with 37% phosphoric acid (Etchant gel, Pegasus, Altrincham, UK) for

30 seconds, rinsed thoroughly with water then air dried<sup>(3,16)</sup>. For all groups, universal adhesive systems (VivaPen, Ivoclar-Vivadent, Schaan/ Lichtenstein), were applied to the prepared tooth surface and scrubbed with micro brush to the surface for 20 second, air thinned, and cured for 10 seconds at a light intensity of 1200mW/cm<sup>2</sup> (Wireless charge LED curing light, Henan China) (4).

### 3.3. Ceramic discs cementation

Resins cement (G-Cem<sup>™</sup> light cure, translucent shade), was used according to manufacturer instructions and applied to the internal surface of the veneer. The ceramic disc was seated into place on the prepared tooth and subjected to a constant load by using a glass slide applied on the

ceramic disc with 100 grams over it for 1 min in order to standardize the thickness of resin cement layer. initial curing with LED curing light was performed for one second in order to remove excess cement<sup>(25)</sup>. The final cure of the cement was accomplished with 40 second with the curing light in

contact with the glass slide <sup>(11)</sup>. After the cementation procedure, the specimens were stored at 37 °C for 48 hours in an incubator in 100% humidity (Electromag; Italy) <sup>(11)</sup>. The materials used throughout the bonding procedure are listed in table (1).

**Table (1):** Adhesive materials used in the study

<b>Luting agent/ Manufacture/Lot</b>	<b>Composition</b>
G-CEM™ Veneer light- cured resin cement (GC Europe N.V.,Tokyo, Japan); LOT: 2101051	4-methacryloxyethyltrimellitate anhydride (4-META), water, phosphoric acid ester monomer, UDMA, initiator, stabilizer, dimethacrylate, silica powder, fluoro-alumino-silicate glass 62%, pigment
<b>Adhesive system</b>	<b>Composition</b>
Universal adhesive; AdheseUniversal, VivaPen, Ivoclar-Vivadent, Schaan, Liechtenstein ;LOT Z00SFL	Bis-GMA, campherquinone, 2-hydroxyethyl methacrylate, ethanol, 1,10-decandiol dimethacrylate, methacrylated phosphoric acid ester, 2-dimethylaminoethyl methacrylate,
Ceramic etching gel; Ivoclar-Vivadent, Schaan, Liechtenstein; LOT: Z006G9	<5% Hydrofluoric acid, purified water and red dye, and thickening agent
Monobond Plus; Ivoclar-Vivadent, Schaan, Liechtenstein; LOT: Z00DTH	Colorless liquid, 3-trimethoxysilylpropyl methacrylaat, ethanol, methacrylated phosphoric acid ester

UDMA: Urethane dimethacrylate; Bis-GMA; Bisphenol diglycidyl ether dimethacrylate.

#### 4. Specimens distribution:

Thirty-disc specimens from (IPS E-max<sup>®</sup>) were divided randomly into three groups (n=10) according to the treatment received as follows:

- Control group (Cont.): No laser irradiation for the ceramic discs.
- Laser group 3Watt (L3): The specimens irradiated with laser at 3watt power.
- Laser group 5Watt (L5): The specimens irradiated with laser at 5-watt power.

#### 5. Laser settings

Irradiation was performed with Er,Cr:YSGG laser (Waterlase MD<sup>®</sup>, Biolase technology, Inc., Irvine, CA, USA), with 2780 nm wavelength with, Gold handpeice, pulse duration 140µs and repetition rate of 20Hz. Laser energy was delivered through a fiber-optic system via MZ6 Zip tip, 600 µm (0.6mm) in diameter and 6mm in length, and the surface bathed with an adjustable air/water spray using a water level of 80% and an air level of 90% <sup>(26)</sup>. In this study, the used tip of the laser

was situated at a 1-mm distance from ceramic discs (non-contact mode) by using a surveyor (Gerdent, Dental materials Co.; Syria). During irradiation, a scanning method perpendicular to the disc surface was used from incisal to cervical border of the disc (one cycle). Each disc surface was irradiated 6 times during the whole 60 seconds irradiation period (average 10 sec./cycle).

## 6. Experimental procedure

### 6.1. Testing of the shear bond strength

The SBS were measured by using “Universal Testing Machine” (Gester, Gester International Co.; China) to assess the shear force needed for veneer disc debonding, for the control and laser irradiated groups. The specimens were placed in the mounting jig that allowed the specimen to be loaded parallel to the adhesive interface. The test was performed by applying force at a crosshead speed of 0.5 mm/min parallel to the specimen surface. Force was applied to the laminate incisogingivally, producing a shear force at the laminate–tooth interface. The force required to debond the veneers were recorded in newton (N) and converted to megabascal (MPa), as explained in the following equation <sup>(27)</sup>.

$$\text{SBS} = \text{F}/\text{A}$$

Where: **SBS**= Shear bond strength (MPa).  
**F**= Load at failure (Newton). **A**= ( $\pi r^2$ ) = (19.63 mm<sup>2</sup>).

### 6.2. Mode of failure:

A stereoscope (Optika Microscopes; Italy) at 10X magnification was used for failure mode examination that was classified according to the Adhesive Remnant Index (ARI) scores, as follows:

- No adhesive left on enamel= Score 0
  - Less than half of the adhesive left on enamel= Score 1
  - More than half of the adhesive left on enamel= Score 2
  - All the adhesive left on enamel= Score 3
- (26).

The images of each specimen after debonding were taken using Optika digital camera (Italy) attached to the microscope. Image J computer program was used to measure the surface area of the remaining adhesive resin cement on the tooth surface.

**Statistical analysis:** The normal distribution of data was verified by performing normality tests (Shapiro- Wilk and Kolmogorov-Smirnov). The results showed that abnormal distribution of data (nonparametric) because of two groups ( $\alpha < 0.05$ ) for the two tests. Therefore, the Kruskal-Wallis test was applied to compare the SBS of the three groups. The Mann-Whitney test was used for pairwise comparisons between control and laser irradiated groups for each power. The IBM SPSS statistics version 25.0 statistical set was used to convey out all of the statistical analysis. Statistical significance was set at  $\leq 0.05$ . The confidence level was set at 95% for all tests.

## RESULTS

The data in Table (2) showed the normality tests for the groups which explain that abnormal distribution of the groups ( $\alpha=.000$ ) in both tests, therefore nonparametric test was used. Table (3) showed the descriptive statistics of the study groups, in which the control group revealed the highest SBS value while 5watts laser group recorded the least. The result of Kruskal-Walli's test for SBS of the control and laser irradiated groups are illustrated in Table (4) that showed significant differences between groups ( $\alpha=.000$ ). Control group recorded

significantly higher mean SBS (10.6450 MPa) required to debonded ceramic disc compared to laser groups at 3watts (1.93924 MPa) and 5 watts (0.9720 MPa). A bar graph representing the mean SBS for all groups is shown in Figure (3). The result of Mann-Whitney test (Table 5) for comparison between each two-group yielded significant difference between control (Cont.) and the laser irradiated L3 ( $\alpha =.000$ ), and significant difference between Cont. and L5 ( $\alpha =.000$ ), while there was no significant difference between the two laser groups (3 and 5 W) ( $\alpha =.418$ ).

**Table (2):** Tests of Normality for the groups

Group	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Cont.	.108	10	.200*	.968	10	.875
L3	.293	10	.015	.810	10	.019
L5	.423	10	.000	.652	10	.000

Two of the three groups have  $\alpha \leq 0.05$  (nonparametric)

**Table (3):** Descriptive statistic for SBS (MPa)

Group	N	Mean	SD	SE	Min.	Max.
Cont.	10	10.6450	1.14857	.36321	8.83	12.31
L3	10	1.5820	1.43924	.61324	.00	4.98
L5	10	.9720	.84020	.51868	.00	4.16

SD= Standard deviation; SE= Standard error

**Table (4):** Kruskal-Wallis H test

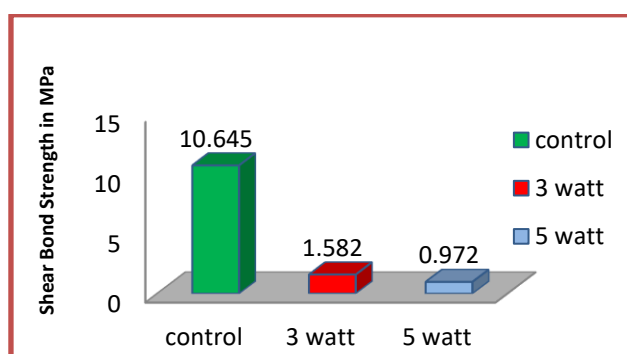
Group	Mean(MPa)	N	$\alpha$ -value
Cont.	10.6450	10	
L3	1.5820	10	.000*
L5	.9720	10	

\* Significant as  $\alpha < 0.05$  ( $\alpha=.000$ )

**Table (5):** Mann-Whitney U test

Group	N	$\alpha$ -value
Cont. versus L3	10	.000*
Cont. versus L5	10	.000*
L3 versus L5	10	.418

\* Significant as  $\alpha < 0.05$  ( $\alpha = .000$ )



**Figure (3):** Bar graph of the mean SBS

During laser irradiation, some of ceramic discs debonded before the end of 60sec. irradiation time. Descriptive statistics for the time at which debonding occurred are illustrated in Table (6) in which the least mean time for debonding was recorded in L5 group (10.4286 second), while the mean time in L3 group (17.4000 second). To

compare between the time of debonding discs of the two laser groups, independent sample t-test were used (Table 7). However, there was no significant difference between the time for debonding discs of the two laser groups ( $\alpha = .135$ ), as  $\alpha > 0.01$ .

**Table (6):** Descriptive statistic for the time in seconds for the ceramic discs that completely deboned during laser irradiation

Group	N	Mean(second)	Range	SD	SE	Min.	Max.
L3	5	17.4000	25.00	10.23719	2.57821	9.00	34.00
L5	7	10.4286	14.00	4.42934	1.67413	6.00	20.00

**Table (7):** Independent sample T- Test for time in seconds of the completely deboned discs during laser irradiation of the two laser powers

Time	T-value	df <sup>^</sup>	$\alpha$ -value	Mean Difference	Std. Error Difference
L3 versus L5	1.625	10	.135	6.97143	4.29051

<sup>^</sup> df = Degree of freedom.

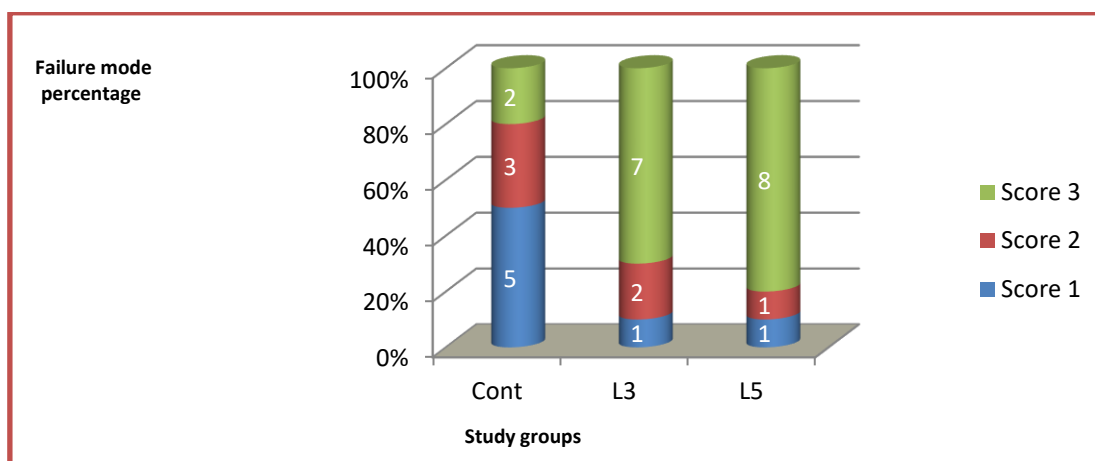


Mode of failure frequency and percentages are shown in Table (8) and Figure (4). The control group recorded 50% of score 1 (less than 50% of the adhesive left enamel), 30% of score 2 (more than 50% of the adhesive

left on enamel), and 20% of score 3 (all the adhesive left on enamel). However, both laser groups (L3 and L5) recorded mainly scores of 2 and 3, which mean more adhesive remnants left on enamel.

**Table (8):** Frequency distribution and percentages of failure mode

Group	Score 1	Score 2	Score 3
Cont.	5 (50%)	3 (30%)	2 (20%)
L3	1 (10%)	2 (20%)	7 (70%)
L5	1 (10%)	1 (10%)	8 (80%)



**Figure (4):** Bar graph for failure mode

## DISCUSSION

This study aimed to investigate the efficacy of Er,Cr:YSGG laser in the debonding of lithium disilicate (E-max<sup>®</sup>) veneers using two laser powers. Bovine teeth can be used as a suitable substitute for both enamel and dentin substrates for permanent and deciduous human teeth<sup>(28)</sup>. Bovine teeth have a relatively large flat surface without caries lesions or defects that may affect outcomes<sup>(29)</sup>.

The Er,Cr:YSGG emits a pulse beam of energy at a wavelength of 2.78μm<sup>(30)</sup>.

Erbium family lasers (Er,YAG and Er,Cr:YSGG) have wavelengths matching to the peak absorption of water and hydroxyapatite, which results in a water-mediated ablative impact<sup>(31)</sup>. The laser debonding procedure for all ceramic restorations is suggested to be a relatively easy and harmless technique when compared to traditional techniques<sup>(20)</sup>. Tak *et al.*<sup>(32)</sup> assessed the ceramic materials and dental hard tissues by light microscopy after the debonding process and they observed that the bonding between the

ceramic restoration and the tooth was disrupted mostly at the ceramic/cement interface, leaving most of the inner surface of the ceramic veneer free of luting cement. Alikhasi *et al.*<sup>(16)</sup> observed that there were no ablation hollows or even minor marks of ablation on the tooth surface. Pich *et al.*<sup>(33)</sup> reported that the laser debonding process did not change the chemical surface composition of dental ceramics. The laser energy passes through ceramic materials and is absorbed by the water and residual monomer that present in the luting cement, resulting in debonding of all- ceramic restorations<sup>(34)</sup>. Many studies have used different power parameters by changing laser energy, frequency, application duration and mode of Er,Cr:YSGG lasers<sup>(1,6,20,23,27,35)</sup>. In their laboratory study, Zanini *et al.*<sup>(1)</sup> used lithium disilicate laminates with three different luting agents (Variolink Veneer, RelyX U200, and RelyX Veneer). Then laminate veneers were debonded using Er,Cr:YSGG laser (2.78  $\mu\text{m}$ ), non-contact mode, with two different protocols: 3.0 W, 40 J/cm<sup>2</sup>, 20 Hz and 3.5 W, 48.14 J/cm<sup>2</sup>, 20 Hz. The authors concluded that “the Er,Cr:YSGG laser is effective for removing lithium disilicate laminates without causing damage or photoablation in enamel prisms, and the presence of cement remnants after debonding, as detected by optical coherence tomography (OCT) and energy-dispersive X-ray spectroscopy (EDS) techniques, evidenced that the thermal and ablative effects promoted by irradiation

only in the cement layer, which suggests that the protocols used may be suitable for future clinical application”<sup>(1)</sup>. In their laboratory study Tak *et al.*<sup>(32)</sup> used five different resin cements: Multilink Automix, G-Cem LinkAce, Panavia F, Variolink II, and Rely X Unicem U100, the ceramic discs dimensions were 1mm in thickness, and 5mm in diameter, and prepared from a lithium-disilicate reinforced glass, and used an Er:YAG laser at 600mJ, 2 Hz (1.2W) and 1,000ms pulse duration (Energy density 45.4 J/cm<sup>2</sup>). The authors evaluated the debonding of ceramic veneers with different resin cements, concluded that” all composite resin cements were affected by the laser irradiation resulting in the volume loss of the cement that varied according to the resin cements tested. Multilink Automix and G-Cem resin cements were significantly more affected by the Er:YAG laser irradiation than the other resin cements tested.” This phenomenon was explained as an effect of “photoablation” and “thermal ablation,” which produce hydrodynamic vaporization and expulsion of the resin<sup>(32)</sup>. The result of our study that there is a significant difference between the laser groups and control in reducing SBS, which is in agreement with previous studies<sup>(6,11,16,22)</sup>. As there was a significant difference between the control and the laser-irradiated groups, therefore the first null hypothesis was rejected. There was no significant difference between the two powers used, which agrees with the results

of a previous studies<sup>(6,11)</sup>. Since no significant difference was evident between the two laser powers used (3 and 5 W), therefore, the second null hypothesis was accepted.

There were a number of discs that were completely separated during laser irradiation in the laser -treated groups, which agrees with previous studies<sup>(11,27)</sup> that may be attributed to the ablative effect on the cement that is rapidly generated by irradiation with the laser<sup>(27)</sup>.

The laser technique for veneer removal avoids the physical contact with veneers, therefore reducing fracture risk<sup>(36)</sup>. In our study, there was no fracture of any of the ceramic discs, which agrees with previous studies<sup>(7,16,37)</sup>.

In debonding studies, the mode of failure is an important index of where failure occurs and assesses the probable risks of enamel damage<sup>(26)</sup>. After laser irradiation, bond failure occurred mostly at the resin– ceramic interface or within the resin, which means preserving the teeth structures from iatrogenic damage, in contrast to traditional debonding methods where the failure is more likely at the resin–enamel interface<sup>(38)</sup>. The results of our study on the mode of failure of laser -irradiated groups mostly scored 2 and 3, indicating that the outer surface of the resin cement was softened by the laser and the debonding location was between the ceramic / resin interface, compared with the control group that scored 1(50%) in addition to score 2 (30%) and score 3

(20%), indicating that the debonding location was mostly between the tooth and resin cement. This could increase the risk of tooth damage, which is in agreement with previous studies<sup>(16,17,37)</sup>. Erbium lasers can be considered as a promising tool and valued for the removal of all ceramic restorations<sup>(5)</sup>.

## CONCLUSIONS

Within the limitations of the current in vitro study, it can be concluded Er,Cr:YSGG could be a safe, effective, fast, and harmless method for the reduction of the SBS to debonded E-max<sup>®</sup> laminate veneers without affecting the tooth and the veneer itself. Since there was no significant difference in the reduction of SBS when 3- and 5-watts laser powers used, it is advocated to use 3 watts.

## Declaration of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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