Al-Rafidain Dental Journal, Vol. 23, Issue No.1, 2023 (187-200)

Al-Rafidain Dental Journal

rden.mosuljournals.com

A different Laser powers and their Assisted in Ceramic Veneers Removal: (An in vitro Study)

Bydaa A. Abood[1], Abduladheem Raouf Sulaiman[2]

[1] Ministry of Health/ Nineveh Health Directorate

[2] Department of Conservative Dentistry, College of Dentistry, University of Mosul

Article information

Received: August 7, 2021
Accepted: September 30, 2021
Available online: March 20, 2023

Keywords
Ceramic Veneer
Er,Cr:YSGG laser
Debonding
Resin cement

***Correspondence:**
E-mail:
Bydaa.dep36@student.uomosul.edu.iq

Abstract

Aims: To evaluate the efficiency of an Er Cr: YSGG laser in debonding of veneers made of lithium disilicate (E-max®) as measured with the shear bond strength (SBS); determine the effect of two laser powers on the SBS required to debonding veneers, and finally determining the mode of failure for all groups. **Materials and methods**: Thirty ceramic discs (1mm in thickness and 5mm in diameter) were prepared according to the manufacturer's instructions. The outer surfaces of enamel for thirty bovine teeth were made flat and the discs cemented onto these prepared surfaces through using luting agent (choice 2 light cure) (Bisco, Inc, Schaumburg IL, USA). Samples were stored in distilled water for 24hours, after which they were divided randomly into three equal groups (n=10) according to the laser power used as follows: Cont.: for the control group that wasn't subjected to laser irradiation; L3: For group irradiated at 3 watt (60 sec.); L5: For group irradiated at 5 watt (60 sec.). SBS was measured by Instron universal testing machine and the failure modes were evaluated by using stereomicroscope. Results: Both lasers irradiated groups (3 and 5 watts) showed significant reduction in SBS required to debonding veneers as compared to the control group (α=.000). However, there was no significant difference between the two laser powers. Conclusion: Er,Cr:YSGG could be a safe, effective, fast and harmless method for the removal of E-.max® laminate veneers, as it caused significant reduction in SBS required for debonding of cemented veneers. Since there was no significant difference between the two laser powers therefore three watts may be advocated.

الخلاصة

الأهداف: تهدف الدراسة الى تقييم كفاءة ليزر Er Cr: YSGG في فك ارتباط القشور الخزفية المصنوعة من مادة السيراميك (E.max) lithium disilicate®مقاسة بقوة ربط القص, وكذلك تحديد تاثير قوتين من الليزر(3 و 5 واط) على قوة القص المطلوبة لفك ارتباط القشور الخزفية, واخيرا فحص طبيعة الفشل. **المواد وطرائق 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 2 Choice™ الراتنجي. تم خزن النماذج في الماء المقطر لمدة 24 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 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 لازالة القشور الخزفية دون التاثير عليها او على الاسنان, وحيث انه لم تكن هناك فروقات معنوية بين قوتي الليزر(3 و 5 واط) , لذا ننصح بإستخدام قوة 3واط.

DOI: 10.33899/RDENJ.2023.131324.1131

INTRODUCTION

Ceramic veneer (CV) are the most durable, reliable, and suggested restorative material for anterior teeth, since the 1980s [(1)], especially with the continuous progress of adhesive techniques[(2)]. In esthetic dentistry, forming a life like smile is a continuous challenge which is dependent on factors including, tooth substrate, luting cement, shade matching, ceramic type, and technical skills [(3)]. Many new developments are made to aesthetic dental procedures related to the manufacture, cementation, maintenance and removal of ceramic laminates[(4)]. As all dental restorations, the CV may need to be removed at variable intervals duo to many causes such as dental decay, sensitivity, pain, lack of aesthetics, periodontal response problems, in addition to failures during the cementation process, or malposition [(1,5,6)]. These conditions shoves the dental professionals to remove restorations, that may require cutting the veneers or even drilling them completely giving the difficulty of their removal, that may lead to full destruction of the restorations [(7)]. Because of high bond strength of resin cement both to the tooth structure and ceramic material, in addition the lack of contrast between them, this may lead to veneer destruction combined with tooth destruction underlying veneer [(8,9)]. Ultrasonic was another conventional method used for veneer removal through special scalar tips[(10)]. The drawbacks of using ultrasonic are: CV may get fractured, time consuming approach, greater possibility to damage the substructure, tips can inadvertently move away from the boundary and the long axis of the teeth/ veneer, the periodontal tissues, and heat created may be have untoward effect to the teeth structures[(11,12)]. So, it is motivating to study debonding options without the damaging neither the tooth nor the fixed prostheses[(7)]. The use of a laser eliminates the problems of debonding that are associated with the conventional methods [(13)]. The use of laser has been successfully applied for ceramic orthodontic brackets debonding from tooth surfaces by Strobl *et al.* [(14)]. After a few years, the use of lasers to remove ceramic veneers and crowns was reported [(15,16)]. Lasers such as Er Cr: YSGG, 2,780 nm wavelength could be used for harmless removal of all ceramic fixed prosthesis [(4)]. The procedure is relatively fast and there is no iatrogenic hazard for the underlying teeth substrate. Laser was suggested to be used as an alternative method for removal of ceramic veneers [(1)]. Studies have suggested that erbium laser's energy may be transmitted through the ceramic and selectively absorbed by water rich substances molecules such as residual monomers in the luting cements, resulting in reduced SBS [(17–19)]. Therefore, the aims beyond the current research are to evaluate the efficacy of an Er,Cr: YSGG laser in debonding of veneers made of lithium disilicate (E-max®) as measured with the SBS; determine the influence of two laser powers (3 and 5 watt) on SBS required to debonding veneers and study the mode of failure. The first null hypothesis to be tested was that irradiation with Er,Cr: YSGG laser had not effect on SBS to debonding veneers, while the second null hypothesis was that there is no significant difference between two powers of laser irradiation in reducing SBS.

MATERIALS AND METHODS

1. Specimen's collection and preparation

The study was accepted by Research Ethics Committee board (University of Mosul, College of Dentistry, REC reference No. (UoM. Dent/ A.L.25/21).
Freshly extracted mandibular incisors (n=30) from (2–3) years old bovine were obtained from a local abattoir to be used in the study. Criteria of the teeth selected were that they had no crown cracks or fractures, enamel defects or caries [5,20]. To assess that the crowns were without cracks, the teeth were visually examined with light transillumination. They were cleaned from any attached soft tissues and scaled by using scaler then polished with fluoride-free pumice (Bilkim LTD/ Turkey)[2]. Crowns were cut at the cementoenamel junction with a carbide disk, the root part discarded and the pulp tissues in the crown part were removed with barbed broach and the canal space cleaned with normal saline and dried [21]. The teeth were stored in distilled water at room temperature until further processing, not more than one week [13]. Autopolimerizing cold cure resin (Veracril Cold Curing Dental Polymer, New Static , Antioquia-Colombia) cold cure resin was mixed according to the manufacturer instructions and poured in a cylindrical plastic tube of 2.5cm in diameter and 2.75cm in height, after which the specimens were embedded in acrylic resin (Figure 1) such that the outer surface of the enamel was facing upward [5,16]. After the completion of polymerization, the outer 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 s .Then samples were immersed in dental ultrasonic bath for 3 minutes in order to remove any abrasive grain present in the specimen[8]. The specimens were stored in distilled water at room temperature [22].

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® press, Ivoclar Vivadent®, Schaan, Liechtenstein) shade A2 LT (low translucency). Discs of 1± 0.05mm in thickness and 5 ± 0.02 mm in diameter were prepared according to manufacturer instructions, using heat pressed technique. The discs dimensions are checked using a digital caliper (Figure 2).

Figure (2): A: Ingot of E-max press®; B: Measuring the thickness of ceramic discs using digital caliber, C: Measuring the diameter of ceramic disc.

3. Cementation:

3.1. Ceramic surface preparation:

The internal surfaces of ceramic discs were etched by the application of IPS® Ceramic Etching Gel (4% hydrofluoric acid) (Ivoclar, Vivadent) for 30 sec. [23]. Then, washed thoroughly with water (20 sec.) and ultrasonicly cleaned in distilled water for 5 min. [23], dried with oil-free air, after which monobond Plus silane (Ivoclar, Vivadent®, Schaan, Liechtenstein) was applied onto the internal surfaces of the discs for 1 min. and allowed to air dry [21].

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 and air dried [20]. For all groups, universal adhesive system (VivaPen, Ivoclar-Vivadent, Schaan, Lichtenstein; LOT: Z006G9) was applied to the prepared tooth surface and scrubbed with micro brush on the surface for 20 sec, air thinned, and cured for 10 seconds by LED light curing unit (Henan, China) at a light intensity of 1200mW/cm^2 [24].

3.3. Ceramic discs cementation

Resins cement (Choice™2 LC, Bisco, USA) (LOT no.1900004751; composition: Bis-GMA, > 90% Strontium glass, Amorphous silica) translucent shade was used according to manufacturer instructions and applied to the internal surface of the veneer. The veneer was then seated into place on the prepared tooth and the ceramic disc was subjected to a constant load by using a glass slide applied on the ceramic disc with a 100 grams over it for 1 min in order to standardize the thickness of resin cement layer[25]. An initial cure was made for one second in order to remove excess cement. The final cure of the cement will be accomplished with 40 second with the curing light in contact with the glass slide[26]. After cementation procedure, the samples were stored at 37°C for 24 hours in 100% humidity in an incubator (Electromag; Italy) [27].

4. Specimens distribution:

Thirty disc specimens from (IPS E-max®) 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.

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®, Biolase technology, Inc., Irvine, CA, USA), with 2780 nm wavelength with pulse duration 140**µs** and repetition rate of 20 Hz. Laser energy was delivered through a fiber- optic system via MZ6 Zip tip, 600 µm (0.6mm) in diameter and 6mm in length (a new tip used for each two samples) and the surface bathed with an adjustable air/water spray using a water level of 80% and an air level of 90% [1]. In this study, the application tip of the laser was placed at 1-millimeter 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 "shear bond strength"

The "SBS was measured using Universal Testing Machine "(Gester, Gester International Co.; China) to evaluate the shear force needed for veneer disc debonding, for the control and laser irradiated groups. The specimens were placed in a specially designed mounting jig that allowed it to be loaded parallel to the adhesive interface (Figure 3). The force was applied at the adhesive interface using a crosshead speed of 0.5 mm/min. in an incisogingival direction. The force required to deboned the veneers was registered in newton (N) and then transformed into Megepascals (MPa), as explained with the following equation: [28]

S=F/A;

Where: **S**= Shear bond strength (MPa). **F**= Load at failure (N). **A**=Surface area of the disc (πr^{2}) = 19.63 mm^2.

6.2. Mode of failure:

A stereoscope (Optika Microscopes; Italy) at 10X magnification was used for failure mode examination that was categorized according to the Adhesive Remnant Index (ARI) scores, as follows: [29]

No adhesive remaining adhered to enamel= Score 0

Less than half of the adhesive remaining adhered to enamel= Score 1

More than half of the adhesive remaining adhered to enamel= Score 2

All the adhesive remaining adhered to enamel= Score 3

The images of each sample after debonding were taken using Optika digital camera (Italy) attached to the microsope. Imagej computer program was used to measure the surface area of the remaining adhesive resin cement on the tooth surface[30] (Figure 4) represent score 1,2, and 3 respectively.

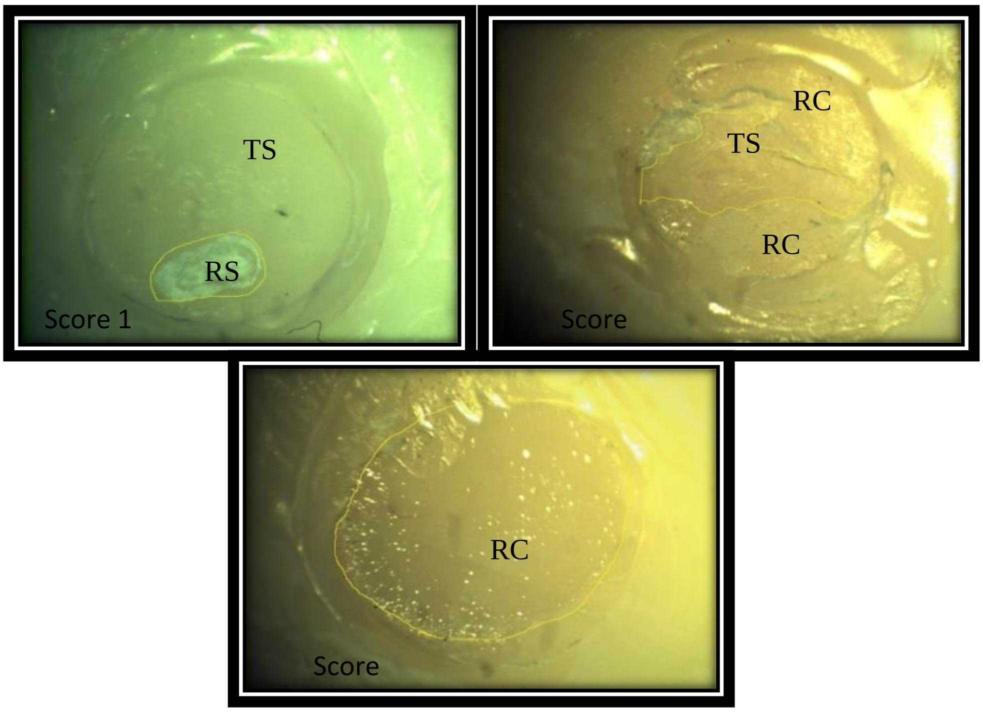

Figure (4): Adhesive remnant scores for the mode of failure evaluations.

Statistical analysis:

The normal distribution of data was verified by performing normality tests (Shapiro- Wilk and Kolmogorov-Smirnov), the result showed that normal distribution of the data (α=.361 and= 200 respectively). Therefore, One-way analysis of variance (ANOVA) tests followed by, Duncan Multiple Analysis Rang Test. The IBM® SPSS® program version 25.0 statistical analysis was used to perform the statistics. Significance value was set at $\alpha \leq 0.05$. The confidence level was set at 95% for all tests.

RESULTS

The result of normality test are listed in Table (1) which showed that normal distribution of the data $\alpha > 0.05$. Descriptive statistics for SBS of the test groups are listed in Table (2) in which the control group revealed the highest value while 5watts laser group recorded the least. One way ANOVA and Duncan Multiple Analysis Rang Test for the mean SBS of the control and laser irradiated groups are illustrated in Tables (3) and (4) respectively that showed significant differences between groups. Control group recorded significantly higher SBS (12.3250 MPa) required to deboned ceramic disc compared to laser groups at 3watts (5.8360 MPa) and 5 watts (5.4880 MPa). However, no significant difference existed between both laser irradiated groups. A bar graph representing the mean SBS for all groups is shown in Figure (5).

Table (1): Tests of Normality for the groups

Group	Tests of Normality					
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Cont.	.186	10	.200*	.885	10	.148
L3	.194	10	.200*	.931	10	.459
L5	.206	10	.200*	.920	10	.361

α>0.05 therefore normal distributions (parametric).

Table (2): Descriptive statistics for the shear bond strength (MPa) of test groups

Group	N	Mean	SD	SE	Min.	Max.
Cont.	10	12.3250	1.53154	.48432	10.66	15.21
L3	10	5.8360	.91267	.28861	4.05	6.90
L5	10	5.4880	1.00066	.31644	3.61	6.86

Table (3): Analysis of variance (ANOVA) for the SBS of test groups

	Sum of Squares	df	Mean Square	F	α-value
Between Groups	296.576	2	148.288	106.429	.000**
Within Groups	37.619	27	1.393		
Total	334.195	29			

** Signifcant as $\alpha < 0.05$; df = Degree of freedom

Table (4): Duncan Multiple Analysis Rang Test for the test groups

Group	N	1	2
L5	10	5.4880	
L3	10	5.8360	
Cont	10		12.3250
Sig.		.515	1.000

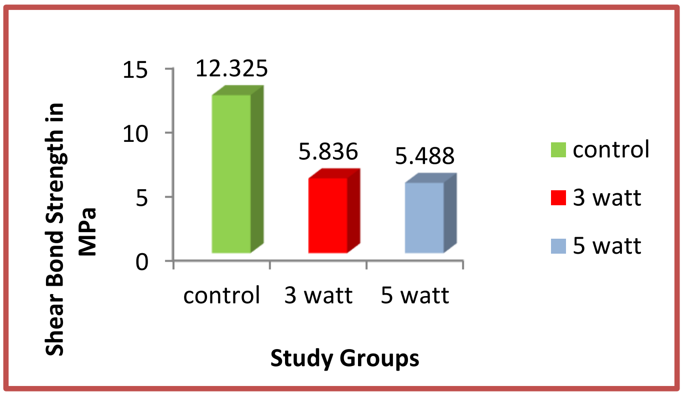

Figure (5): Bar graph for the mean SBS of the study groups.

Mode of failure frequency and percentages are shown in Table (5) and Figure (6). The control group recorded equally scores of 1 (Less than 50% of the adhesive residual cement adhered to enamel) and 2 (More than 50% of the adhesive residual cement adhered to enamel) with 50% for each. However, both laser groups (L3 and L5) recorded mainly scores of 2 (More than 50% of the adhesive residual cement adhered to enamel) and score 3(All the adhesive remaining adhered to enamel); in L3 (40% score 2, and 50% score 3), while in L5 (50% score 2, and 40% score 3).

Table (5): Frequency distribution for failure modes and their percentage for the study groups

Group	Score 1(percentage)	Score 2 (percentage)	Score 3 (percentage)
Cont	5 (50 %)	5 (50 %)	0
L3	1 (10 %)	4 (40 %)	5 (50%)
L5	1 (10 %)	5 (50%)	4 (40%)

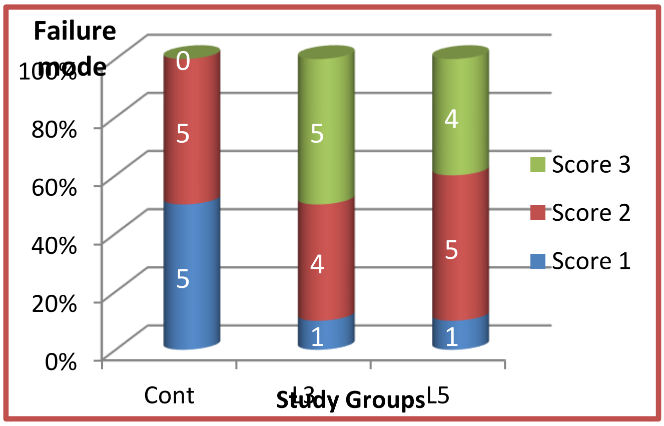

Figure (6): Bar graph for the numbers of failure mode of E-max® groups

DISCUSSION

Bovine teeth were used in this research as it can be considered as a suitable substitute for human teeth for bond strength tests [30]. Bovine teeth are easier to handle due to their large size producing standardization and high reproducibility for shear bond strength tests [31].

The Er,Cr:YSGG emits a pulse beam of energy at a wavelength of 2780nm [32]. This wavelength, which falls into the mid-infrared (IR) range resembles the peak absorption range of the water curve that lies in the mid-infrared spectrum [33]. In recent years, the usage of lasers in prosthetic applications such as the removal of all-ceramic restorations with different parameters (e.g. laser power, water/air ratio, energy and frequency) have been increasing, being one of the important topics [27]. Er, Cr: YSGG laser have several benefits in debonding laminate veneers because of the operator's ability to alter the settings (power, energy, frequency, air /water_percentages, the irradiation method, and time) which could aid in protecting the tooth surface and avoiding increasing the pulp chamber temperatures [34]. The depth of preparation of the tooth surface, the type of ceramic material and the thickness of the restoration should be taken into consideration when choosing the laser parameters for debonding[27]. Most of the studies used different power parameters, by changing laser energy, frequency, application duration and mode.[4,8,17,22,35)]

Morford *et al*.[36] used an Er:YAG wavelength at a low repetition rate of 10 Hz, and energy setting of 133, 217, 316, 400, 503 mJ (1.33 W – 5W) with a small pulse duration of 100 µsec, the average irradiation for removal time was 106 ± 59 sec. The authors performed the Fourier-Transformed Infrared Spectroscopy (FTIR) after the irradiations and verified that the Er:YAG laser was not powerfully absorbed by the ceramic materials so, might be passed through the laminate. The authors concluded that the use of the laser results in a safe method for the laminate removal[36] that mean the laser energy not absorbed by ceramic materials or poorly absorbed, therefore transmitted through the ceramic and reach the residual monomer and water that present in luting resin that lead to reduce the shear bond strength or debonding the veneer completely by one of the three assumed mechanism thermal softening, photoablation and thermal ablation. Oztoprak *et al*.[6] used the Er: YAG laser 5 W, 50 Hz, 100 mJ/pulse, with a 1 mm diameter tip at a 2 mm distance from the surface of the laminates during 3, 6, and 9 second for debonding lithium disilicate veneer restoration luted with variolink veneer resin cement. The authors concluded that the irradiated ceramic laminates had lower shear bond strength[6]. Iseri *et al*. [16] in their laboratory study, used Er:YAG laser; 100 mJ. However, a higher frequency was used, 50 Hz, the used tip (1 mm in diameter) was placed perpendicularly at 2 mm distance from the porcelain laminate veneer (PLVs) made from lithium disilicate discs (5 mm in diameter, 0.7 mm in height). The authors concluded that a laser-aided debonding using a scanning method was effective for debonding laminate veneers and an Er:YAG laser effectively reduced the SBS of laminate veneers, facilitating their removal [16]. Gurney *et al.* [35] in their laboratory study, used a "lithium disilicate" crown restorations, which was cemented with resin cement, an Er,Cr:YSGG laser was used at different wattages "(3, 3.5, 4, and 5 W) with 30, 60, and 90 second applied time", using 60% air, 30% water, and 25 Hz, with the aim of determining the most effective power and exposure time for the removal of lithium disilicate crowns. The authors found that using 3.5 and 4 Watts of power over 60 seconds could result in the removal of the restoration without producing pulp damage[35].

During laser irradiation of ceramic veneer for debonding, laser energy is absorbed by residual monomer in the cement, and degradation of cement can occur by one of the three assumed mechanisms, as explained by Tocchio[37] : thermal softening, thermal ablation, and photoablation. Photoablation and thermal ablation happens when high energies are used[27]. The Er,Cr:YSGG laser works on the principle of micro explosion during tissue ablation resulting in microscopic and macroscopic irregularities, and softening of luting cement[22]. As an established technique for veneer removal, it avoids the physical contacts with veneers, therefore reducing fracture risk of veneer [3]. In our study, no ceramic disc was fractured during laser irradiation or during SBS test which indicates that the use of laser for assisted removal of CV restoration may preserve the veneer restoration and can be rebounded if needed, which agrees with other studies[3,17,21,35]. Kellesarian *et al.* [38] stated that the main purpose of debonding of all CV restorations by lasers is to decrease the bond of the resin to the ceramic substrate. The scanning method by moving the hand piece horizontally over the entire surface of the CV restoration with a specific time, frequency and specific energy will reduce the SBS needed for veneer removal, and prevent temperature rise [13]. The reduction in the SBS required to deboned ceramic discs is in agreement with other studies[6,7,27,28,36]. As there is significant difference between the control and the laser irradiated groups, the first null hypothesis was rejected. The result of this study in that there was no significant difference between the two laser powers in reducing the SBS agree with the result of Morshedi *et al.* [27]. Since there is no significant difference between the two powers used (3, and 5 watt), the second null hypothesis was accepted.

In debonding studies, the mode of failure is an important index of where the failure occurred and evaluates the probable risks of enamel damage[1] . After laser treatment, bond failure occurred commonly at the resin– ceramic interface or within the resin that means preserving the tooth structure from iatrogenic damage, which is opposite to traditional debonding methods where the failure is more likely at the enamel– resin interface [(34)]. The result of our study for 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 laser and the debonding location was between resin/ceramic interface, compared with the control group that scored 1 in addition to score 2 indicating that the debonding location was mostly between the tooth and resin cement. This could increase the damage risk to the tooth, which is in agreement with other studies[(21,28,36)]. It is therefore tempting to speculate that erbium lasers are a probable tool and valued for the removal of all ceramic fixed dental prosthesis[(38)].

CONCLUSION

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 debonding E-max® veneers. Since there was no significant difference in the reduction of SBS when 3 and 5 watts laser powers were used, 3watts may be advocated.

REFERENCES

1. Yilmaz BD, Polat ZS, Izgi AD, Gunduz DT, Dirihan RS. The contribution of ceramic thickness and adhesive type on the de-bonding strength of dental ceramic veneers using Er,Cr:YSGG laser. *J Oral Res*. 2020;8(2):131–9.
2. Gaeed SA, Ali SAA. Failures of porcelain laminate veneers using different techniques of bonding (A comparative in-vitro study). *JODR*. 2017;4(1):35–46.
3. Albaker AM, Al Deeb L, Alhenaki AM, Aldeeb M, Al Ahdal K, Abduljabbar T, et al. Bonding integrity and compressive strength of re-bonded, surface conditioned and Er Cr YSGG laser treated lithium disilicate ceramics. *J Appl Biomater Funct Mater*. 2020 ;18(1):1–7.
4. Zanini NA, Rabelo TF, Zamataro CB, Caramel-Juvino A, Ana PA, Zezell DM, et al. Morphological, optical, and elemental analysis of dental enamel after debonding laminate veneer with Er,Cr:YSGG laser: A pilot study. *Microsc Res Tech*. 2020;1(16):1–10.
5. Cifuentes HG, Gómez JC, López Guerrero AN, Muñoz J, Guerrero ANL, Muñoz J. Effect of an Er , Cr : YSGG Laser on the Debonding of Lithium Disilicate Veneers With Four Different Thicknesses. *J Lasers Med Sci*. 2020;11(4):464–8.
6. Oztoprak MO, Tozlu M, Iseri U, Ulkur F, Arun T. Effects of different application durations of scanning laser method on debonding strength of laminate veneers. *Lasers Med Sci.*

2012;27(4):713–6.

7. Al-maajoun MK, Escuin Henar T, España Tost A, Ascaso Terren C. CO2 and Er,Cr:YSGG Laser Applications in Debonding Ceramic Materials: An in Vitro Study. Open *J Dent Oral Med*. 2017;5(3):25–30.
8. Zanini N, Rabelo TF, Zamataro CB, Caramel A, Kuchar NG, Castro PAA De, et al. Effect of Er , Cr : YSSG laser on dental Veneers removal submitted to gamma radiation. *Int Nucl Atl Conf*. 2019;1(1):1819–30.
9. Karagoz-Yildirak M, Gozneli R. Evaluation of rebonding strengths of leucite and lithium disilicate veneers debonded with an Er:YAG laser. *Lasers Med Sci*. 2020;35(4):853–60.
10. Zhang Y, Rocca JP, Fornaini C, Zhen Y, Zhao Z. Erbium Doped , Yttrium Aluminum Garnet Laser Debonding of Porcelain Laminate Veneers : An Ex vivo Study. *Contemp Clin Dent*. 2020;9(4):570–3.
11. Bajunaid SO. Review of techniques for the intact removal of a permanently cemented restoration. **Gen Dent**. 2017;46(409):48–53.
12. Vasileva R. Techniques for Fixed Dental Restorations Removal - Classification, Decision on the Correct Approach, Advantages and Disadvantages. *J IMAB* . 2021;27(1):3510–7.
13. Hamadah O, Bachir W, Zamzam M. Thermal Effect of Er:YAG Laser Pulse Durations on Teeth During Ceramic Bracket Debonding. *Dent Med Probl*. 2016;53(3):352–7.
14. Strobl K, Bahns TL, Willham L, Bishara SE, Orth D, Stwalley WC. Laser-aided debonding of orthodontic ceramic brackets. *Am J Orthod Dentofac Orthop*. 1992;101(2):152–8.
15. Buu N, Morford C, Finzen F, Sharma A, Rechmann P. Er:YAG laser debonding of porcelain veneers. In: Rechmann P, Fried D, editors. *Lasers in Dentistry XVI*. 2010. p. 754909–15.
16. Iseri U, Oztoprak MO, Ozkurt Z, Kazazoglu E, Arun T. Effect of Er:YAG laser on debonding strength of laminate veneers. *Eur J Dent*. 2014 ;08(01):058–62.
17. Alkhurays M. Influence of Different Luting Cements on the Shear Bond Strength of Pretreated Lithium Disilicate Materials. *J Contemp Dent Pract*. 2019;20(9):1056–60.
18. ALBalkhi M, Swed E, Hamadah O. Efficiency of Er:YAG laser in debonding of porcelain laminate veneers by contact and non-contact laser application modes (in vitro study). *J Esthet Restor Dent*. 2018 May;30(3):223–8.
19. Connor W. Non-Invasive Retrieval of Prefabricated Zirconia Crowns with Er, Cr: YSGG Laser from Primary and Permanent Teeth. *Virginia Commonwealth UniversityVCU Scholars Compass*, Master Thesis; 2020:1-50.
20. Alikhasi M, Monzavi A, Ebrahimi H,

Pirmoradian M, Shamshiri A, Ghazanfari R. Debonding Time and Dental Pulp Temperature With the Er, Cr: YSGG Laser for Debonding Feldespathic and Lithium Disilicate Veneers. *J Lasers Med Sci*. 2019;10(3):211–4.

21. Giraldo-Cifuentes H, España-Tost A, Arnabat-Dominguez J. Er,Cr:YSGG Laser in the Debonding of Feldspathic Porcelain Veneers: An In Vitro Study of Two Different Fluences. *Photobiomodulation, Photomedicine, Laser Surg*. 2020;38(10):640–5.
22. Vohra F, Alghamdi A, Aldakkan M, Alharthi S, Alturaigi O, Alrabiah M, et al. Influence of Er: Cr: YSGG laser on adhesive strength and microleakage of dentin bonded to resin composite. In-vitro study. *Photodiagnosis Photodyn Ther* . 2018 ;23(38):342–6.
23. Alhamzah NB, Alsahil NH, Afzal I, Naseem M, Alqahtani I, Vohra F, et al. Influence of Hydrofluoric Acid Etching, Resin Bonding and Resin Removal Treatments on the Surface Roughness of Ceramics. *Biosci Biotechnol Res Commun*. 2020 ;13(1):43–7.
24. Calabro DE, Puglisi R, Mikail A, Mesquita M, Paulo US, Paulo S. Removal of 11 Laminate Veneers with Er-Yag Laser. *J Dent Sci*. 2019;7(1):63–9.
25. Agarwal SK, Singhal R, Hussain S, Kalpana K, Khurana P. Evaluation of bond strength of a heat pressed ceramic to resin cement after various surface treatment : an in vitro study. Eur *J Pharm Med Res*. 2020;7(9):545–9.
26. Morshedi E, Zavaree MA, Hakimaneh SM, Shayegh SS, Pirmoradian M, Torabi S, et al. Effect of Er:YAG laser irradiation on shear bond strength of two porcelain laminate veneers bonded to tooth surface. *J Islam Dent Assoc Iran*. 2020;32(1–2):21–9.
27. Gozneli R, Karagöz Yıldırak M, Ok Tokaç S, Özkan Y. Effects of Different Er:YAG Laser Parameters on Debonding Forces of Lithium Disilicate Veneers: A Pilot Study. *Eur J Res Dent*. 2019;1(3):8–13.
28. Cifuentes HG, Gómez JC, López Guerrero AN, Muñoz J. Effect of an Er , Cr : YSGG Laser on the Debonding of Lithium Disilicate Veneers With Four Different Thicknesses. *J Lasers Med Sci*. 2020;11(4):464–8.
29. Romano FL, Pessoti G, Galo R, Gomes-Silva JM, Lucisano MP, Borsatto MC, et al. Does the CO2 laser reduce bond strength in different types of ceramic brackets? *Dental Press J Orthod*. 2017 ;22(2):55–60.
30. Sohail A, Elmahallawi O, Sedky Y, Ghanem L. The Effect of different power settings of Er,Cr:YSGG Laser on Tooth Structure Chemistry and Topography and time of Debonding of Laminate Veneers : “In Vitro Study.” *J Fundam Clin Res*. 2021;1(1):187–93.

31. Arango-Santander S, Montoya C, Pelaez-Vargas A, Ossa EA. Chemical, structural and mechanical characterization of bovine enamel. *Arch Oral Biol*. 2020;109(2020):104573–6.
32. Silva EJNL, Carvalho NK, Prado MC, Senna PM, Souza EM, De-Deus G. Bovine teeth can reliably substitute human dentine in an intra-tooth push-out bond strength model? *Int Endod J*. 2019 ;52(7):1063–9.
33. Quinto J, Amaral MM, Francci CE, Ana PA, Moritz A, Zezell DM. Evaluation of Intra Root Canal Er,Cr:YSGG Laser Irradiation on Prosthetic Post Adherence. *J Prosthodont*. 2019;28(1):e181–5.
34. Deeb JG, Bencharit S, Dalal N, Abdulmajeed A, Grzech-Leśniak K, Golob J, et al. Using Er:YAG laser to remove lithium disilicate crowns from zirconia implant abutments: An in vitro study. Mishra YK, editor. *PLoS One*. 2019 ;14(11):e0223924.
35. Hoteit M, Nammour S, Zeinoun T. Evaluation of Enamel Topography after Debonding Orthodontic Ceramic Brackets by Different Er,Cr:YSGG and Er:YAG Lasers Settings. *Dent J*. 2020;8(1):6.
36. Gurney ML, Sharples SD, Phillips WB, Lee DJ. Using an Er,Cr:YSGG laser to remove lithium disilicate restorations: A pilot study. *J Prosthet Dent*. 2016 ;115(1):90–4.
37. Morford CK, Buu NCH, Rechmann BMT, Finzen FC, Sharma AB, Rechmann P. Er:YAG laser debonding of porcelain veneers. *Lasers Surg Med*. 2011;43(10):965–74.
38. Tocchio RM. Iàser Debonding of Ceràmic Orthodontic Bràckets. *The UníversitY of Manitoba Departnent of Preventive Denta1 Science Irlinnipeg, Manitoba canada*; 1993.
39. Kellesarian SV, Ros Malignaggi V, Aldosary KM, Javed F. Laser-assisted removal of all ceramic fixed dental prostheses: A comprehensive review. *J Esthet Restor Dent*. 2018 ;30(3):216–22.