AJDS ALAZHAR
Al-Azhar Journal of Dental Science
Vol. 24- No. 1- 19:26- January 2021
Print ISSN 1110-6751 | online ISSN 2682 - 3314
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Restorative Dentistry *(Removable Prosthodontics, Fixed Prosthodontics, Endodontics, Dental Biomaterials, Operative Dentistry)*

DEBONDING OF LITHIUM DISILICATE AND FELDSPATHIC VENEERS WITH ER, CR: YSGG LASER BONDED WITH TWO DIFFERENT CURING MODE RESIN CEMENT

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ABSTRACT

Objective: The purpose of this study was to evaluate the debonding of feldspathic and lithium disilicate reinforced glass ceramic veneers using Erbium lasers with two different curing mode resin cement. **Materials and Methods:** In this study, a total of 80 ceramic specimens were used. They were divided into two groups (n= 40/group) according to ceramic material used into: Group (A) lithium disilicate (IPS Emax), Group (B) Feldspathic porcelain. (VITA MARK II). Each group was further subdivided into two subgroups according to the cement curing mode (n= 20/subgroup): Subgroup (L) Light cured resin cement, Subgroup (D) Dual cured resin cement. Er,Cr:YSGG (turbo handpiece) was used on all subgroups. Scanning electron microscope and Profilometer were used to evaluate surface tomography & roughness. Data was analyzed statistically. **Results:** For surface roughness of two ceramics at base line and after debonding .There was no statistically significant difference between median (Ra) values of the two ceramics (*P*-value=0.754, Effect size=0.199), (*P*-value= 0.825, Effect size=0.155) and (*P*-value=0.117, Effect size=0.245). As for the curing mode: both materials showed no statistically significant effect of curing modes (*P*-value = 0.425, Effect size = 0.051) and (*P*-value = 0.543, Effect size = 0.065), respectively. **Conclusion**: Based on the limitation of the current study ; the following conclusions can be drawn: Er, Cr: YSGG fluid dynamic laser system is an effective clinical application for the debonding of resin-bonded all-ceramic restorations. The surface topography of both ceramic materials almost the same after debonding which make their future use possible.

KEYWORDS: Laser debonding, ceramic veneers, different curing modes

INTRODUCTION

People find that smile is the first characteristic recognized in interpersonal communication, among which a beautiful smile is regarded as having high self-esteem. Dentistry has undergone tremendous changes in the past few decades, from just treating toothache to reaching the best cosmetic standards. Nowadays, dental aesthetics has become a challenge due to all the influences of people's frequent exposure to the media[1, 2].

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DOI: *10.21608/ajdsm.2020.48964.1134*

Nowadays, a variety of esthetic restoration are available in the dental practice. The most popular restoration is ceramic veneer, which has the ability to adhere to the tooth structure, has less occlusal wear relative to the tooth, and the most important aesthetic feature[3].

The microstructure of the ceramic determines the optical and mechanical properties of the restoration. As the glass content increases, this will provide excellent aesthetics, but the mechanical properties are lower; on the other hand, when the filler increases, the mechanical properties will also increase, showing lower translucency. In order to take combine both the strength and aesthetic performance, a high-strength layered technology is used. With the advancement of fabrication techniques the use of feldspathic porcelain and lithium disilicate fabricated by CAD/CAM or monolithic lithium disilicate fabricated by heat pressed technology had gained a lot of interests[4].

Commonly used materials for ceramic veneers are Emax and Feldspathic porcelain. These types of ceramics have achieved popular esthetic traits in the dental field. Emax and Feldspathic restoration are mainly fabricated by CADCAM technology, so they are very durable. In addition, these materials can be used in relatively very thin sections, so diminishing the need for unnecessary tooth removal. In fact, this feature gave the rise of the minimally invasive restorations concept[5].

However, some local failures may occur, such as discoloration, micro-leakage, slotted edges or simple fractures, so repair or replacement is required. Recently, by using Er: YAG laser the ceramic laminate veneer peeling technology were developed inspired by their application on orthodontic ceramic brackets since the 1990s and their successful debonding [6,7].

Therefore, the necessity to study the possibility of debonding ceramic veneers and their surface properties after debonding became a must. In order to provide the best clinical recommended procedures for easy debonding and re-bonding procedures.

MATERIALS AND METHODS

Specimen grouping and study design:

In this study, a total of 80 ceramic specimens were used, which were divided into two groups (n= 40/group) according to ceramic material used into:

- Group (A) lithium disilicate (IPS Emax) (Ivoclar Vivadent AG, Liechtenstein)
- Group (B) Feldspathic porcelain. (VITA MARK II) (VITA Zahnfabrik, Germany)
- Each group was further subdivided into two subgroups according to the cement curing mode (n= 20/subgroup):
- Subgroup (L) Light cured resin cement (RelyX Veneer)
- Subgroup (D) Dual cured resin cement. (RelyX ultimate clicker)

Preparation of the ceramic samples:

The Isomet machine was used to cut the ceramic blocks, resulted in having 40 square specimens from IPS Emax blocks and another 40 discs from Vita Mark II blocks with dimension 10×10 mm and thickness 0.7 mm, size was reassured by using digital caliper.

Fabrication of acrylic blocks

Special mould was prepared for each bovine tooth, the ice cube mould was used to be filled with cold cure acrylic resin; color coded for ease of differentiation between groups. Vaseline was applied on the moulds before cold cure acrylic resin was poured to act as a separating medium then cold cure acrylic resin was poured in the moulds and before complete setting the teeth were fixed in the cold cure acrylic resin. Further finishing was done.

Teeth Preparation and bonding procedures:

Freshly extracted bovine teeth stored in saline, labial surfaces of the teeth were initially prepared by placing depth orientation grooves (0.3 mm) in depth, and labial surface was flattened by a customized paralleling device assembly for preparation standardization**.** Then etched with phosphoric acid 37% (gel) (Scotch Bond phosphoric acid etching gel ,3MESPE, Neuss, Germany) for 30 seconds then rinsed with air-water jet for 30 seconds. Bonding agent (Adper Single bond 2 3MESPE, St.Paul, USA) was applied and activated 15 seconds then light cured according to manufacture instructions. Ceramic samples were etched by HF acid (ITENA Porcelain Etch, Paris, France) 9.5% for 20 seconds then rinsed with air and water spray and silinated according to manufacture instructions.

The teeth stored in saline for preservation of the teeth without any effect on its grapheme and also removal of any debris .Ceramic discs were bonded on freshly extracted bovine teeth directly after treatment to mimic the intraoral situation with 50 (N) perpendicular load using a dental surveyor was placed on the external surface of the veneer after cement application for 30 seconds and light activated for 40 seconds LED curing light with an 11-mm-diameter tip positioned 1.0 mm from the veneer surface. After the cementation procedure, the specimens were stored in distilled water at 37 °C for 24 h to mimic intraoral situation.

Laser debonding:

Laser beam was applied of wavelength 2780nm using the following settings for each group: Operation Mode is Free Running Pulse, Hand piece :turbo(MX7) ,Repetition rate 20 Hz , Power 4.5 W , Pulse duration (60µs) H mode, Air 60% ,Water 80% and Non-Contact mode 5mm away .The turbo hand piece positioned perpendicular to veneer surface at a distance verified by custom made positioner for standardization of energy density.

Scanning Electron Microscope Evaluation

After laser debonding procedures were applied, random samples for each group of ceramic were taken to examine surface tomography and evaluate atomic composition using a scanning electron microscope with magnification 20,000X. The debonded ceramic discs was first mounted on aluminum stubs and sputted with a gold layer using sputter coater and then evaluated.

Profilometer:

Surface roughness (Ra) of randomly chosen ceramic specimens was evaluated by using the Profilometer. The Ra value was statistically analyzed and compared between the ceramic discs at base line and after debonding with laser beam.

Statistical analysis:

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). Surface roughness (Ra) data showed non-normal (non-parametric) distribution. Non-parametric data were presented as median and range values. Kruskal-Wallis test was used to study the effect of curing on (Ra). Dunn's test was used for pair-wise comparisons. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

RESULTS

Surface roughness (Ra):

Comparing between the two ceramics at baseline and after debonding: There was no statistically significant difference between median (Ra) values of the two ceramics (*P*-value=0.754, Effect size=0.199), (*P*-value= 0.825, Effect size=0.155) and (*P*-value=0.117, Effect size=0.245).

Effect of different curing modes:

IPS E.max as well as Vita Mark II ceramic; both shows no statistically significant effect of curing modes (*P*-value = 0.425, Effect size = 0.051) and (*P*-value = 0.543, Effect size = 0.065), respectively.

TABLE (1): The median, range values and results of Mann-Whitney U test for comparisons between the two ceramics and Kruskal-Wallis test for the effect of curing on surface roughness (Ra).

Curing Mode	IPS E.max		VITA		*P*-value (Between ceramics)	Effect size *(d)*
	Median	Range	Median	Range		
Base line evaluation	35.7	29.2-38	29.6	13.6-43.8	0.754	0.199
Light cure resin cement	30.4	16.5-34.5	31.3	15.3-41.4	0.825	0.155
Dual cured resin cement	30.9	22.4-35.2	25.8	13.4-30.9	0.117	0.245
***P*-value (Effect of curing)**	0.425		0.543			
Effect size *(Eta squared)*	0.051		0.065			

Significant at (P ≤ 0.05)

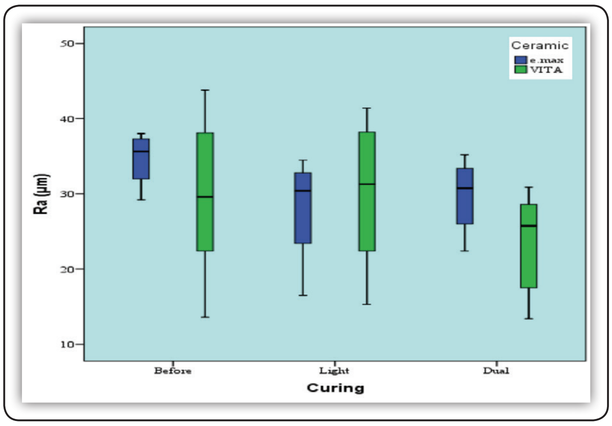

FIG (1) Box plot representing median and range values of surface roughness (Ra) in the different groups (Circle represents outlier).

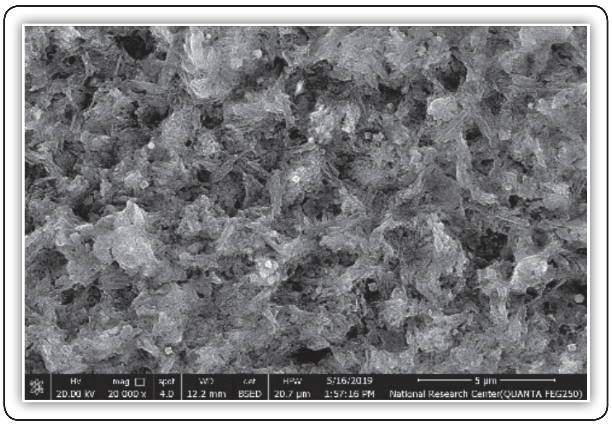

FIG (2) IPS Emax evaluation at baseline. (20,000X)

Scan Electron Microscope Evaluation

The SEM images revealed:

- The IPS Emax showed the typical lithium disilicate crystals embedded in a glass matrix, rod shaped that are interlocked and haphazardly organized.

- The VITA MARK II showed a microstructure based on aluminum, potassium and sodium based silicate with grains of about 4 µm, very porous material, described as honeycombed surface.

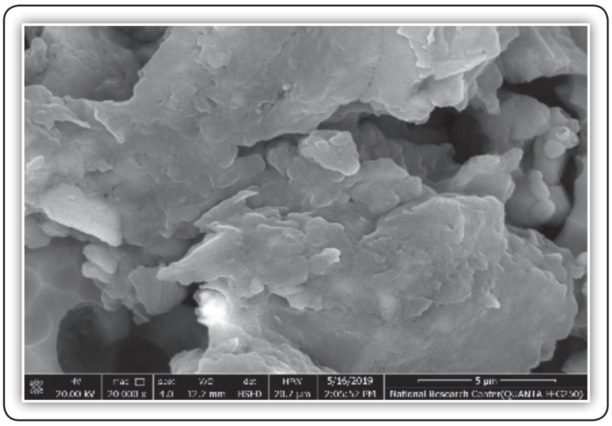

FIG (3) VITA MARK II evaluation at baseline (20,000X)

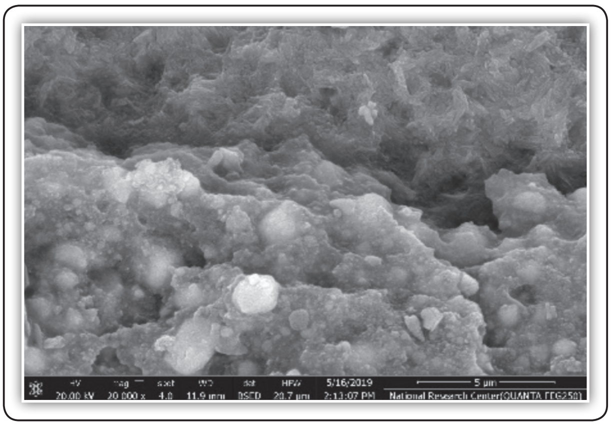

FIG (4) IPS Emax cemented by Light cure resin cement evaluation after laser debonding procedures. (20,000X)

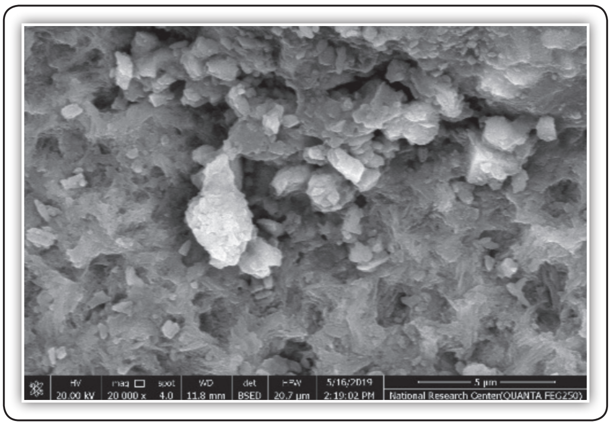

FIG (5) IPS Emax cemented by Dual cure resin cement evaluation after laser debonding procedures. (20,000X)

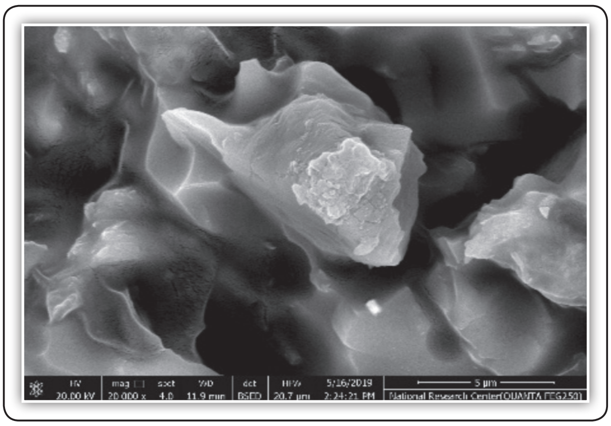

FIG (6) VITA MARK II cemented by Light cure resin cement evaluation after laser debonding procedures. (20,000X)

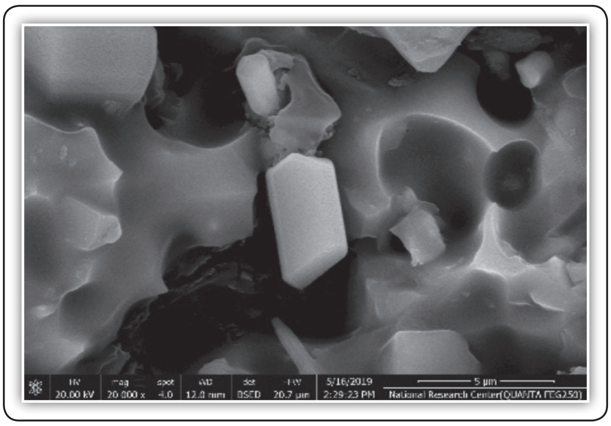

FIG (7) VITA MARK II cemented by Dual cure resin cement evaluation after laser debonding procedures. (20,000X)

DISCUSSION

Porcelain veneer restorations were introduced as a conservative and reliable aesthetic restoration in the early 1980s. They has excellent clinical performance, and therefore became one of the most predictable, beautiful and least invasive treatment methods. Among the routinely ceramic materials: glass-based feldspar ceramics and lithium disilicate, which have excellent optical effects by imitating the characteristics of natural enamel and dentin, good aesthetics and mechanical properties [8].

The desire for longer-lasting esthetics is not limited to improving the types of materials, but also not limited to improving bonding solutions such as adhesives. Generally, these types of restorations are bonded by an adhesive, and its bond to the tooth structure is considered to be effective and strong, as it depends on micromechanical bonding[9].

However, with the latest developments in materials and technology, failures still exist. Many factors can cause ceramic repair failure. Many of these failures are related to the manufacture of the restoration, others are related to the bonding procedure or the experience of the practitioner. Therefore, these failures can easily occur during the operation of the function, leading to re-production purpose[10].

Since the removal step is considered an arduous and time-consuming process, and due to the lack of color contrast between the tooth, the adhesive resin interface and the restoration, traditional techniques still pose risks to the underlying tooth structure[11].

Recently, laser technology has been introduced as a more comfortable and conservative ceramic veneer removal technology. One of its advantages is to overcome the limitations of traditional technology, because it relies on the thermal effect of the laser to soften the adhesive resin based on the adhesive and absorb water-rich substances like monomer[2]. However, there are very few studies published in this field. Therefore, it is of great significance to study the recyclability of the ceramic veneers debonded using Er, Cr: YSGG laser.

In this in vitro study, lithium disilicate (IPS E.max) and feldspar porcelain (Vita Mark II) were selected, because these two materials have unique microstructures and therefore have satisfactory aesthetics and mechanical performance. The first one consists of a glass matrix that is infiltrated by micron-level crystals of lithium disilicate to form a highly filled glass matrix, while vita mark II is composed of fluorapatite crystals in aluminosilicate glass [5].

Electric saw (Isomet) was used to cut out specimens from LT A1 CAD/CAM blocks, so that sample thickness is standardized for all groups, at 0.7mm one of the recommended thicknesses required for all ceramic veneers[2, 12]. In this study, to mimic natural bonded surface and hardness of dental substrate, we used freshly extracted bovine teeth, and it is considered as an alternative to natural teeth in dental research[13, 14].

Ceramic discs were bonded with resin adhesive; to help strengthening the ceramic restoration, in the subgroup of light curing resin cement (relay x veneer)[15, 16], and for representing different curing modes the other group was cemented using dual cure resin cement (Relay x ultimate clicker)[17, 18].

Each group used the following settings to apply the laser beam power :2780nm wavelength: 4.5 W, repetition frequency: 20 Hz, pulse duration (60µs) H mode, air: 60%, water: 80%, non-contact mode 5mm remote handpiece : Turbo (MX7 fiber tip with a spot diameter of 700 µm focusing distance)as an advantage compared to 50 Hz and 100 mJ used by Oztoprak et al [19].

Since the distance between the laser head and the surface affect the quality of the laser as documented in literature. It was recommended to set the distance to 3-5 mm[2], in agreement with the research of Albalkhi et al.

Laser application is carried out by scanning method, perpendicular to the surface of the disc, moving in a clockwise direction from the outer circle to the center of the cemented disc sample along the disc, repeat this process until the pen under the veneer triggers a sound and feels different[17].

Ergin et al., evaluated the influence of cavity preparation with different Er,Cr:YSGG laser handpieces on microleakage of different posterior composite restorations[20] so it was of high interest to test the turbo handpiece significance in debonding porcelain laminate veneers.

Among different types of surface roughness parameters, R_a gives a representative estimate of surface roughness and it is easy to be calculated [21]. In this study, it was carried out with a contact profiler, which is located between the peaks and valleys of the surface. The surface roughness was measured by the baseline (after sectioning) and after the laser lift-off protocol. [22]

Morford et al., pointed out that future scanning electron microscopy studies will need to provide better detailed information about the enamel surface, and more importantly, provide more detailed information about the veneer surface after laser stripping to evaluate the veneer due to the ablation process Possible change or damage[23].Therefore, we used laser debonding technique, which reduces the required forces to prevent the risk of tooth and ceramic damage, and examined in the present study by SEM images at 20,000x magnification.

Comparing the baseline and Ra value after peeling, the two ceramics had no statistically significant effect. No signs of damage or ablation or ablation pits were found on the surface of the ceramic laminate. Simultaneously with the study by Morford et al., he mentioned the photomicrograph of incident light and found that the bond between the veneer and the enamel was mainly destroyed at the veneer cement interface, thus making most of the surface of the veneer clean, this observation also emphasizes that laser ablation rather than thermal softening of cement can be achieved during debonding of the veneer [23]. Keeping in consideration the mode of action of mentioned wavelength mainly operates by absorption of the laser energy in the water.

It can be concluded that the Er, Cr: YSGG laser energy is transmitted through the veneer, to the resin cement absorbing the final transmitted energy, thereby ablating the cement. When enough cement is burned from the veneer, it will slip off the surface of the tooth. We can also say that the curing method of cement has nothing to do with the debonding step, which is completely related to the water content of the resin cement rather than any of its other components. Now, we can safely say clean intact laser debonding can be achieved. Moreover, it is highly recommended to always use a powerful air-water cooling spray for pulp safety.

The limitation of this study was its in vitro design allowing different condition than intraoral situations but also gave us the opportunity to examine each factor solely without the effect of other factors.

The use of laser debonding on ceramic veneer gave us a very promising modality for veneer debonding and rebonding further studies should be carried out in order to set the parameters for its use. Also, other ceramic materials and restorations should be examined.

CONCLUSION

Based on the limitation of the current study; the following conclusions can be drawn:

1. Er, Cr: YSGG fluid dynamic laser system is an effective clinical application for the debonding of resin-bonded all-ceramic restorations.
2. The surface topography of both ceramic materials nearly stayed stable after debonding protocol, allowing their future reuse.

ACKNOWLEDGEMENT

Authors are highly grateful to Dr.Marwa Mohamed Wahsh, Associate Professor of Fixed Prosthodontics, Fixed Prosthodontics Department, Faculty of Dentistry, Ain Shams University For her generous contribution in the guidance and enrichment of this research.

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