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DEBONDING OF CERAMIC BRACKETS BONDED TO LITHIUM DISILICATE GLASS-CERAMICS (E-MAX) USING CONVENTIONAL TECHNIQUE VERSUS ER:YAG AND ER,CR:YSGG LASERS

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ABSTRACT

Aim of the study: To evaluate the effect of debonding technique of ceramic brackets on lithium disilicate glass-ceramics (E-Max) using conventional technique versus Er:YAG laser and Er,Cr:YSGG Laser.

Materials and methods: A total of 45 LDC discs (IPS Emax CAD, Ivoclar Vivadent AG, Schaan, Liechtenstein) were fabricated in a dental laboratory with a standard quality control and mounted on acrylic blocks. The specimens were randomly divided into three groups: group I: Non lased group (conventional debonding), group II: Er:YAG laser debonding technique, group III: Er,Cr:YSGG laser debonding technique. The three groups were tested for the shear bond strength (SBS) using Universal testing machine. Scanning Electron Microscopic (SEM) image was made to the LDC IPS Emax specimens before and after debonding of the ceramic orthodontic brackets to evaluate any surface cracks or fractures. Adhesive remnant index (ARI) score was tested using stereomicroscope.

Results: Both group II and group III (lased groups) had significantly lower SBS than the non-lased group (control group). 33.3% of the specimens in group I showed signs of cracking. Only 13.3% demonstrated presence of cracks in group II, while no cracks were found in group III. There were no significant differences in the distribution of ARI scores among the three groups (P=0.64).

Conclusion: Er:YAG and Er,Cr:YSGG laser irradiation on ceramic brackets was efficient and significantly decreased the SBS. Significant presence of cracks on lithium disilicate surface was found in the non lased group. No significant differences were found in the ARI score in all groups.

KEYWORDS: Ceramic brackets, Lithium Disilicate Glass-ceramics (E-Max), Er:YAG laser, Er,Cr:YSGG laser.

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INTRODUCTION

Orthodontic appliances that are fixed and offer both the patient and the orthodontist optimal technical performance are a highly desired combination. The requirement for orthodontic appliances to have the best possible cosmetic look has been emphasized because modern orthodontics treats a large number of people, particularly women. Since their debut in 1986, all of the major orthodontic manufacturers have produced a variety of ceramic brackets, which have grown in popularity and become a necessary tool for clinicians. [1]

Ceramic bracket removal has been a major source of concern. Manufacturers most likely underestimated the initial bond strength needed to hold the bracket in place throughout treatment and failed to consider the variations in debonding methods needed for brittle ceramic and ductile metal brackets. Although the A Company Starfire debonding pliers can be used to remove any bracket, two manufacturers, A Company and Unitek/3M have created specialized tools or pliers for debonding their own ceramic brackets. For this reason, ceramic brackets should only be removed very carefully and in compliance with the manufacturer's instructions [2] . There have been reports of difficulties arising from mechanical debonding treatments, including enamel fractures, fissures, and flaking [1]. It has been noted that one possible side effect of the heat-producing gadgets is pulp irritation. One of the main concerns for the physicians utilizing ceramic braces is tooth or pulp tissue injury.[1] Unfortunately, the ceramic brackets are friable and prone to fractures due to the high modulus and low ductility of the alumina crystals that make them up. [3]. This increases the difficulty and duration of their removal in orthodontic offices and increases the risk of harming the structure of the enamel.

Using diode lasers, CO2, Nd:YAG, Tm:YAP, Er:YAG, Ytterbium fiber, and Tm:YAP could potentially lower this danger.[3] Numerous orthodontic procedures can benefit from the use of lasers, such as scanning systems, welding procedures, gingivectomy, frenectomy, operculectomy, papilla flattening, uncovering temporary anchorage devices, ablation of aphthous ulcerations, and exposure of impacted teeth. They can also be used to accelerate tooth movement, bonding and debonding processes, reduce pain, stimulate bone regeneration, and increase mini-implant stability.[4]

On the other hand, the evolution of the new glass ceramic systems like the E-max restorations, have increased the esthetic outcome highly demanded by adult patients. These restorations are well known for their superior esthetics, bonding durability and excellent fracture resistance to occlusal forces.[5]

Hence, this study was conducted to find out the best debonding technique of ceramic brackets bonded to the recent E-max restorations that will answer patients' questions about how debonding will affect the restoration's shade and shape after finishing the orthodontic treatment.

MATERIALS AND METHODS

This in vitro study was conducted using a total of 45 LDC discs (IPS Emax CAD, Ivoclar Vivadent AG, Schaan, Liechtenstein) (n=45) with dimensions of 10 mm in diameter and 3 mm in thickness. They were fabricated in a dental laboratory with a standard quality control and mounted on acrylic blocks. The debonding technique was used to randomly divide the specimens into three groups: Group I: Non lased group (conventional debonding), group II: Er:YAG laser debonding technique, group III: Er,Cr:YSGG laser debonding technique.

Specimens' surfaces had been made flat and polished to a smooth finish. The discs were immersed in distilled water for 5 minutes to eliminate residual material, subsequently rinsed in 95% ethyl alcohol for 2 minutes, and then air-dried. Self-curing acrylic resin was mixed and poured into polypropylene pipe rings, The LDC discs were embedded in the self-cured acrylic resin blocks. To get the specimens ready for the following step, they were categorized and given a number. Etching was done for all of the 45 specimens with the conventional method using 9.6% Hydrofluric acid (HF) for 90secs, rinsed with a copious amount of water and then air dried. Two coats of silane coupling agent (Bisco, USA) were applied to all of the 45 etched specimens then dried with warm air syringe after 30 seconds. This was followed by the application of bonding agent (Reliance orthodontic products, Illinois, USA) in a uniform thin coat using special brush then activated with visible light curing system (3M) for 10 seconds. Light cure composite resin material (Reliance orthodontic products, Illinois, USA) was applied .to the base of 45 monocrystalline alumina brackets (HUBIT) which were seated firmly in the proper position in the middle of the LDC disk. Force was applied until the base of the brackets met the labial surfaces of the lithium disilicate glass-ceramics (E-Max) and the composite material overflowed from all of the brackets' edges. The excess adhesive was removed with a hand scaler after which the adhesive was cured using a light cure device (3M) emitting light at wavelength of 400nm for 30 seconds. In order to complete the polymerization process, the specimens were submerged in distilled water at 37 ˊ C for 24 hours.

The prepared blocks with the bonded ceramic brackets were then randomly assigned to one of three groups to be deboned with and without lasing. In the first non-lased group (conventional debonding), using a Universal testing machine (INSTRON no. 3345, USA), debonding force was applied accurately and parallel to the bracket occluso-gingivally by the blade of the Universal testing machine at a speed of 1mm/min [Figure1]. The maximum debonding force was calculated in Newton (N). For the second and the third groups, laser was applied before debonding. Two laser sources were examined in this study: Er,Cr:YSGG and Er:YAG lasers.

For group II, Er:YAG laser (Lightwalker, Fotona) emitting a wavelength of 2.94 µm, average power 2 W, 200 mJ, 10 Hz,Water4%,Air4% for 20 sec was used for bracket debonding. Laser was applied to the ceramic bracket in a non-touching mode scanning method [Figure 2]. The probe was held and secured into place using the hands of the operator, The operator wore protective eyeglasses to protect the eyes from the laser source.

The second laser source was used in group III; Er,Cr:YSGG laser (Waterlase iPlus, Biolase, USA) with 2780-nm wavelength. average power 3W, 25 Hz, Water80%, Air40% for 20 sec. The laser was applied to the ceramic bracket in a non-touching mode scanning method.

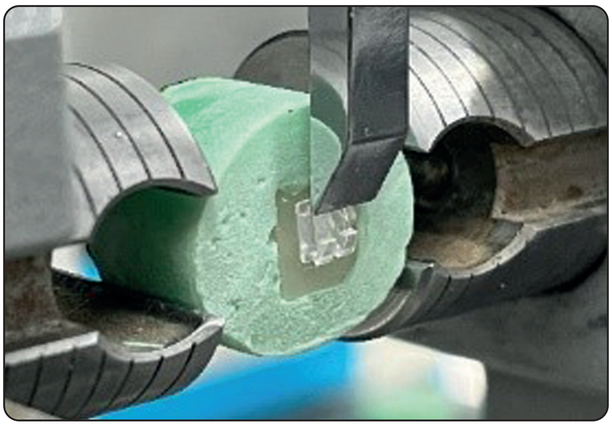

Fig. (1) Debonding of ceramic bracket using Universal testing machine (INSTRON no.3345, USA)

Fig. (2) Ceramic bracket lased with Er,YAG laser

For groups II and III, the Universal testing machine was used to assess the SBS after laser irradiation in the same way as mentioned for group I.

Scanning electron microscope (SEM) (Model FEI Quanta 3D 200i, USA) attached with EDX Unit (Energy Dispersive X-ray Analyses / thermofisher pathfinder) was employed to investigate any surface cracks or fractures after debonding. For the three groups, Scanning Electron Microscopic (SEM) examination images were made during two steps of the study. The first SEM image was made before any surface treatment to the LDC to evaluate any surface cracks or fractures to be the reference for the upcoming SEM images. The second SEM image was made to the LDC IPS Emax samples after debonding of the ceramic orthodontic brackets to evaluate any surface cracks or fractures. Moreover, following debonding, all LDC specimens and ceramic orthodontic brackets were evaluated with a 20X stereomicroscope (Leica MZ12.5, Wetzlar, Germany). The quantity of adhesive remaining on the LDC surface and bracket base were then classified using the modified adhesive remnant index (ARI), based on Artun and Bergland's (1984)[6] ARI system, which assigns the following scores: Score 0: The tooth surface is free of adhesive.

Score 1: awarded for less than half of the adhesive remaining on the tooth surface, and Score 2: awarded for more than half. Score 3: The entire tooth surface covered in adhesive.

Statistical analysis

The SPSS software (version 20.0; IBM, Armonk, NY) was used to conduct the statistical analysis. The normality of numerical data was investigated by examining the distribution of the data and selecting suitable parametric and non-parametric tests using Kolmogorov-Smirnov and Shapiro-Wilk tests. Standard deviation and mean were used to present all quantitative data. $P\leq0.05$ was used as the significance threshold. According to the normality test, all groups' data came from a normal distribution. To compare across all groups in the SBS, the One-way ANOVA test was employed, and for multiple comparisons, Tukey's Post Hoc test was performed. To compare the cracks and ARI score between the groups, Fisher's exact test was employed.

RESULTS

Group I showed the highest values for the SBS, with a mean 11.55 ± 2.44 MPa. Group II and Group III had lower values, with means 8.87 ± 1.51 MPa and 8.96 ± 1.12 MPa respectively. The analysis revealed significant differences in SBS values between group I versus group II and group III, while no significant difference was found between groups II and group III (P=0.988) (Table 1). In group I, 33.3 % of specimens demonstrated presence of cracks. Only 13.3% demonstrated presence of cracks in group II, while no cracks were shown in group III. However ,no notable differences (p=0.052) were found in the presence of cracks between the three groups. There was no noticeable difference in the ARI score distribution across the three groups (P=0.64). (Table 2).

TABLE (1) Comparison of SBS among all groups

Tukey's multiple comparisons test	Mean 1	Mean 2	Mean Diff.	SE of diff.	95.00% CI of diff.	P value Multiple comparisons	P value Overallcomparison
Group I vs. Group II	11.55	8.865	2.681	0.6496	1.102 to 4.259	0.0005*	
Group I vs. Group III	11.55	8.958	2.588	0.6496	1.010 to 4.166	0.0008*	<0.0001*
Group III vs. Group III	8.865	8.958	-0.09267	0.6496	-1.671 to 1.486	0.9888	

TABLE (2) Comparison of mode of failure by the ARI index among all groups

Scores	G1		G2		G3		P value
	Count	Column N %	Count	Column N %	Count	Column N %	
Score 0	5	33.3%	6	40.0%	8	53.3%	0.64
Score 1	10	66.7%	9	60.0%	7	46.7%	
Score 2	0	0.0%	0	0.0%	0	0.0%	
Score 3	0	0.0%	0	0.0%	0	0.0%	

DISCUSSION

The introduction of ceramic brackets in 1986 provided a visually appealing alternative to metal brackets. However, their lower fracture toughness and higher bond strength compared to metal brackets have led to the recognition of debonding as a clinical issue.[1] Pliers are commonly employed for the purpose of debonding ceramic brackets; yet their use carries the risk of inducing enamel fractures and bracket breakage. In order to enhance the process of debonding ceramic brackets, it is necessary to decrease the SBS. The application of laser radiation results in a reduction in the SBS due to the degradation of the adhesive resin utilized for bracket bonding. [7]

This study compares the effectiveness of using Er: YAG, Er,Cr:YSGG lasers and conventional technique in debonding ceramic brackets and it is effect on Lithium Disilicate Glass-ceramics (E-Max) which is now one of the most commonly used materials for the construction of aesthetic fixed restorations.

Surprisingly lasers have been involved in dental research since 1963**.** Many specific areas of laser applications in dentistry have been identified, Thermal or photochemical techniques can be employed to break down the bonding resin by means of laser light that is transmitted to the contact between the adhesive and bracket.[8] In the current study, two laser sources were used, the first was Er:YAG laser; emitting a wavelength of 2.94 µm, average power 2 W , 200 mJ, 10 Hz,Water4%,Air4% for 20 sec .The second laser source was Er,Cr:YSGG laser; with 2780-nm wavelength,average power 3W, 25 Hz, Water80%, Air40% for 20 sec. **Samih et al**. in a previous study in **2014**[9] used Er,Cr:YSGG laser with two different laser powers; 2,5 W and 3.5 W for 40 seconds before debonding ceramic brackets bonded to human premolar teeth, and compared the results to a third group not lased before debonding. Although in this study the debonding was examined on natural premolars, however, the results were similar to the results of our study, where there was a statistically significant decrease in the SBS in the lased groups compared to the non-lased group. Moreover, they found out that debonding was achieved more effectively in the 3.5 W group because of the higher output level which could be attributed to less energy loss during transmission through the brackets, thus the bond surfaces received the laser energy more effectively.

Mirhashemi et al 2019 [10] concluded that the non-lased group showed higher composite damage during debonding ceramic brackets from composite blocks and there were no significant variations in SBS between the laser-treated (Er: YAG and Er,Cr:YSGG laser with the output power of 3 W, 22/28 for 10 seconds) and control group. In this study both the 2W and the 3W laser irradiations had significantly lower the SBS than the non-lased group (control group).

On examining the second SEM image for all de-bonded lithium disilicate specimens to evaluate the surface morphology, the current study found out that 33.3 % of the specimens of the non-lased group demonstrated presence of cracks, only 13.3%

demonstrated presence of cracks in the Er: YAG laser group, while no cracks were shown in the. Er,Cr:YSGG lased group. Similar results were found by **Mundethu et al 2014** [11] and **Naseri et al., 2020** [12] who concluded that enamel cracks in the laser group were significantly lower than in the control group.

The distribution of ARI scores across the three groups did not differ significantly, according to the study's findings (P=0.64). Some studies found out similar results as **Mirhashemi et al 2019** [10] who found no significant variations in ARI between the laser-treated (Er: YAG and Er,Cr:YSGG laser with the output power of 3 W, 22/28 for 10 seconds) and control group during debonding ceramic brackets from composite blocks. However, **Oztoparak et al. in 2010**[13]came to the conclusion that using Er:YAG laser raised ARI scores, which in turn reduced the likelihood of enamel fracture. Moreover, the results of the study carried by **Samih et al.,2014**[9] showed that the laser groups had almost twice as much adhesive compared to the control group when they used Er,Cr:YSGG laser with two laser power levels (2.5W and 3.5W) to debond ceramic brackets from enamel surface.

CONCLUSION

Er:YAG and Er,Cr:YSGG laser irradiation on ceramic brackets was efficient and significantly decreased the SBS. Significant presence of cracks on lithium disilicate surface was found in the non lased group. In all groups, there were no noticeable differences in the ARI scores.

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