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EFFECT OF DIFFERENT CERAMIC MATERIALS ON DEBONDING TIME WITH DENTIN USING ER, CR:YSGG LASER

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ABSTRACT

Objectives: Comparing debonding time of three different ceramic materials lithium disilicate, ultra-translucent zirconia and hybrid-ceramic with dentin using Er, Cr:YSGG laser application.

Materials and methods: Thirty recently extracted human mandibular molars were selected for study. They were fixed in acrylic resin blocks and their buccal surfaces were ground to expose dentin to provide flat surface for bonding then stored in distilled water at room temperature. Three different ceramic materials used in this study, lithium disilicate glass ceramics, hybrid-ceramic, ultra-Translucent Zirconia. A total of thirty square shaped Samples 4x4mm and 1mm thickness resembling crowns prepared from CAD/CAM (computer aided design/computer aided manufacture) ceramic blocks of these ceramic materials, 10 samples for each material. Samples bonded to dentin using dual cure self-adhesive resin cement (TOTALCEM ITENA, France). Laser debonding of ceramic samples of all three materials using Er,Cr:YSGG laser (Waterlase by Biolase). Data were parametric and showed variance homogeneity, so they were analyzed using independent t-test. The significance level was set at $p<0.05$ within all tests.

Results: Results showed that there was a significant difference between different groups ($p<0.001$). The highest value was found in Vita Enamic samples (160.00±22.91) followed by BruxZir (21.57±5.26), while the lowest value was found in Emax samples (7.00±1.29).

Conclusions: The Ultra translucent zirconia and Lithium disilicate were deboned from dentin using Er,Cr:YSGG laser. Using laser for debonding Ultra translucent Zirconia consumses higher time than for Lithium disilicate. Destruction of hybrid ceramics when it was exposed to Er,Cr:YSGG laser to debond it from dentin.

KEYWORDS: Debonding time, Er,Cr:YSGG laser, hybrid-ceramics, Ultra translucent Zirconia.

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INTRODUCTION

Aesthetic demand is an increasing issue in today's world. Using new esthetic materials with enhanced translucency, strength, and bonding ability to tooth structure such as, lithium disilicate glass ceramics, hybrid ceramics, ultra-translucent and zirconia reinforced glass ceramics and thanks to advancements in dental materials technologies clinicians are now allowed to fulfil patients' needs [1,2].

Lithium disilicate composition contains quartz, lithium dioxide, phosphor oxide, alumina, potassium oxide, and other components which have superior aesthetics and high strength. It has many applications and extensive indications with minimally invasive preparation and adhesive cementation of crowns. It shows clinical long-term success and scientifically documented results with natural-looking esthetics irrespective of the preparation shade[1].

Hybrid ceramic materials introduced to the market as named polymer-infiltrated ceramic network material has been developed which contains a dominant ceramic network (86wt %) strengthened by an acrylate polymer network (14 wt. %). These two networks uniformly mixed with each other. Vita Enamic (Vita Enamic; VITA Zahnfabrik, Bad Sackingen, Germany) is type of hybrid ceramic which has aluminum-oxide enriched, fine-structure feldspar matrix infused by polymer including urethane dimethacrylate (UDMA) and other ingredients. It has been reported that this hybrid material is expected to have many advantages including decreased brittleness, hardness, rigidity, enhanced flexibility, and better machinability and fracture toughness than ceramics. It is intended to create a material with the desired mechanical properties of ceramics and composites, which are conventional restorative materials [2].

The biggest challenge clinicians face when using ceramic materials is the difficulty to retrieve restorations to manage complications due to the hardness of the material and bond strength of resin cement compared with other kinds of restorative materials [3]. Moreover, resin cements can be clear or tooth-colored which makes them difficult to distinguish from tooth structure, so crown removal can involve many rotary cutting instruments and much chair time[4].

Recently, with the technological advance in the dental field, laser applications increased dramatically in the last few years for both hard and soft tissue, that is used in all dental fields, such as caries removal, soft tissue surgeries, tooth canal system disinfection in endodontics and low-level therapy as bio-stimulation for TMJ and facial muscles treatment besides accelerating surgical site healing and orthodontic movements. Lasers such as erbium: yttrium aluminum- garnet (Er:YAG)[5] and erbium, chromium: yttrium-scandium-gallium garnet (Er,Cr:YSGG), have been used to remove restorative materials, including composite resin and ceramics such as orthodontic brackets[6], laminate veneers [7] and crowns[3].

This research conducted to study the Effect of different ceramic materials on debonding time with dentin using Er, Cr:YSGG laser.

MATERIAL AND METHODS

Thirty extracted human molars which were fixed in acrylic resin cylinder blocks, and their buccal surface were ground using slow speed precision saw (IsoMet™ 4000, BUEHLER. USA) to expose dentin to provide flat surface for bonding then stored in distilled water at room temperature. Three different ceramic materials were used in this study, lithium disilicate glass ceramics (IPS Emax CAD by Ivoclar Vivadent, Schaan, Liechtenstein), hybrid-ceramic (Vita Enamic by VITA Zahnfabrik), ultra-Translucent Zirconia (BruxZir® anterior, Glidewell Dental Laboratory, USA). A total of 30 squared shaped samples 4x4mm and 1mm thickness resembling crowns prepared from CAD/CAM (computer aided design/computer aided manufacture) ceramic blocks of these ceramic materials, 10 samples each, group (1) lithium disilicate (IPS Emax CAD), group (2) ultra-translucent zirconia (BruxZir® anterior), group (3) hybrid ceramic (Vita Enamic). Samples of group (1) lithium disilicate were glazed and crystallized in ceramic furnace according to manufacturer recommendations, then allowed to cool in room temperature. While samples of group (2) hybrid-ceramic were finished and polished using a special polishing kit recommended by the manufacturer. Then samples of group (3) ultra-translucent zirconia were sintered and glazed in zirconia furnace according to manufacturer recommendations.

Ceramic surface treatment

Lithium disilicate and hybrid ceramic samples were etched by HF acid (DentoBond Porcelain etch, ITENA, France.) for 20 seconds then rinse the ceramic thoroughly with water for 60 seconds to completely remove the etchant and dry well. Silane was then applied on ceramic surface (DentoBond Porcelain silane, ITENA, France) for 60 seconds according to the manufacture instructions. Ultra-translucent zirconia sample were sand blasted by alumina particles size 150 micron, then Zirconia primer (Z prime plus zirconia primer, BISCO, USA) were applied.

Bonding

Bonding of ceramic samples was performed to expose dentin on prepared samples surfaces using dual curing self-adhesive resin cement (TOTALCEM by ITENA medical, France) fixed using blunt back of hand instrument with constant pressure. The Light cure used was LED.F, WOODPECKER®, its wavelength (420nm~480nm), used in high power mode. Short initial light curing for 3 seconds was used to create a semi-gel state in luting cements for easier excess cement cleanup [8], then excess cement carefully removed at the margins using sharp explorer. Curing was continued for 20 seconds at high power mode.

Laser debonding

Samples were debonded from dentin by Er,Cr:YSGG laser (Biolase Waterlase iPlus 2.0,USA)[3], wave length 2780mm, using the following settings; power: 6W, frequency: 20Hz, 80%Water, 60%Air. Er,Cr:YSGG: Gold Hand piece was selected for the study using MGG6 Saffire tip 600μm diameter, positioned perpendicular to ceramic sample surface at 2mm distance, energy applied by scanning method through surface for 10 seconds with horizontal movements perpendicular to the surface, then debonding checked using explorer every 5 seconds. All samples were checked under magnification using digital microscope (Nikon, Ma100, JAPAN) with magnification 30x for inspection.

Statistical analysis

Numerical data were presented as mean and standard deviation (SD) values. Shapiro-Wilk's test was used to test for normality. Homogeneity of variances was tested using Levene's test. Data were parametric and showed variance homogeneity, so they were analyzed using one-way ANOVA followed by Tukey's post hoc test. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows.

RESULTS

Mean and standard deviation values of results were presented in table (1) figure (1). Inter group comparisons showed that there was a significant difference between different groups ($p<0.001$). The highest value was found in Vita Enamic samples (160.00±22.91) followed by BruxZir (21.57±5.26), while the lowest value was found in Emax samples (7.00±1.29). Post hoc pairwise comparisons were all statistically significant ($p<0.001$).

The result of this study showed that Vita Enamic hybrid ceramic samples had severe surface damage and reduced thickness by application of Er,Cr:YSGG laser for deboning samples luted to dentin surface (figure 2). All samples took much time to debond up to three minutes laser application and about half failed to be deboned.

TABLE (1): Mean ± standard deviation (SD) of debonding time for different ceramic materials.

Debonding time (seconds) (Mean±SD)			*f-value*	*p-value*
Emax	*Vita Enamic*	*BruxZir*		
7.00± 1.29^{C}	160.00± 22.91^{A}	21.57± 5.26^{B}	**270.16**	**<0.001***

Means with different superscript letters within the same row are significantly different; *significant (p<0.05).

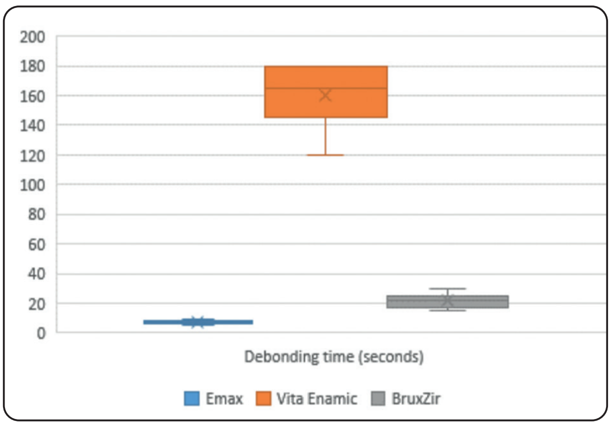

Fig. (1): Bar chart showing mean and standard deviation values for debonding time (in seconds) in different groups.

DISCUSSION:

LASER is a very effective tool full of potentials and applications in all fields of medicine especially dentistry. The invention of hard tissue laser and its properties in reacting with ceramics and resins allowed its use to remove all ceramic restorations in sound condition with minimum time [9]. Laser debonding of ceramic restorations are mostly performed using Er:YAG (2940 nm) and Er,Cr:YSGG (2780nm) laser. It's the most viable and conservative option in debonding keeping the restoration and tooth structure sound in minimum time. It is known that Mid-Infrared lasers are highly absorbed in composite resins and are safe and effective, which is already used for the removal of composite resin fillings [10]. Short-pulsed laser ablation is a promising method for the debonding of all ceramic restorations while avoiding overheating of the pulp. If the cement is rapidly ablated, then heat conduction by the slow thermal softening process can be avoided [11].

Another important factor that affects the efficiency of laser ablation is pulse duration. If the energy required is delivered to the target in a short time, then this energy has limited time to escape from the ablated tissue so less heat diffusion in surrounding tissue. Rising pulse repetition rate during resin removal resulted in a linear increase

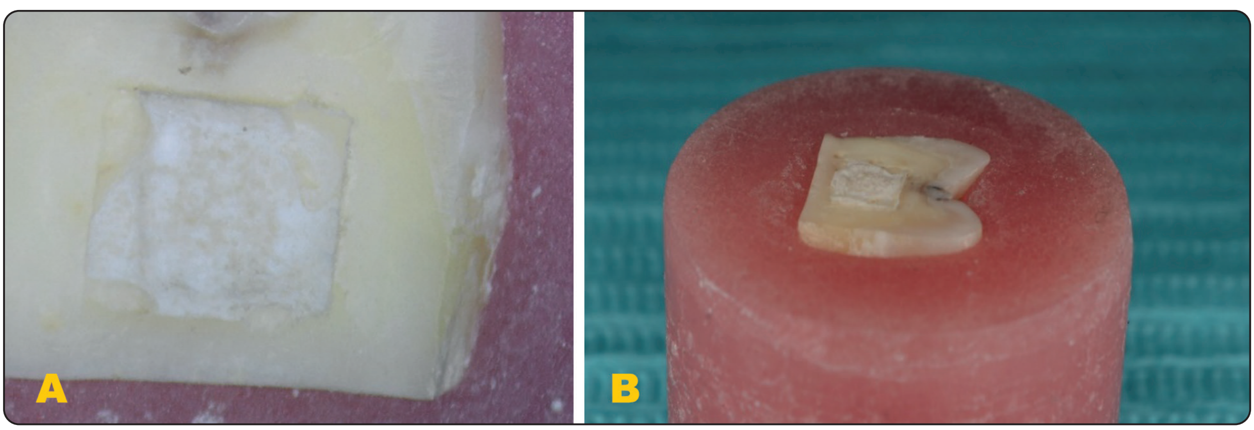

Fig. (2): Vita Enamic samples failed to debond after laser application causing severe damage to ceramic material, a: Surface damage, b: Reduced sample thickness.

in the pulpal temperature, but still does not cause a temperature increase above the safe limit for the pulp vitality [12]. These considerations were taken with in this study by choosing a high-power setting of 6 Watts and decreasing the Frequency (Repetition Rate) to 20 Hz to increase the energy per pulse and to decrease the pulse duration so that the cement is rapidly ablated to avoid heat conduction by slow process of thermal softening.

Material selection for this study was intended to cover the main three families of CAD/CAM all ceramic blocks by choosing the most common material used clinically for each, IPS e.max CAD lithium disilicate for glass-based ceramics group, BruxZir anterior for aesthetic zirconia group and Vita Enamic for hybrid-ceramic group. The dual cured self-adhesive resin cement selected is the most common type of cements used for bonding all ceramic crowns to dentin as its adhesive properties to tooth structure and all ceramic restoration fitting surface creating strong chemical bond, beside that the dual cured property to allow initial activation of cement polymerization by light curing allowing primary retention then the residual un-polymerized resin complete chemically to assure full setting of the cement[13], so it was selected in this study. Samples used in this study were 1 mm thickness square-shaped (4x4mm) CAD/CAM ceramics resembling thickness of crowns bonded to dentin substrate.

In this study, Vita Enamic hybrid ceramic samples had severe surface damage and thining under application of Er,Cr:YSGG laser for samples deboning. This may be due to the composition of Vita Enamic which contains 14% wt. and 25% vol. polymer part [14] as resinous part of the material absorbed most of laser energy not allowing laser beam to reach the self-adhesive resin cement used which cause softening and sever damage of the ceramic surface. The absorption coefficient of laser for Vita Enamic is much higher than laser penetration [15], for that using Er,Cr:YSGG laser for debonding such materials failed to keep the restoration.

Results showed that BruxZir (21.57±5.26) had significantly higher debonding time than Emax (7.00±1.29) ($t=7.12$, $p<0.001$). This may be due to the difference in laser transmission through the different ceramic material because of different composition between lithium disilicate and zirconia ceramics. The laser transmission through lithium disilicate is higher [16], also polycrystalline nature of zirconia ceramics decreases laser transmission through the material [17] so delivering lower energy to resin and dentin. This was agreement with Rechmann P et al in 2014[4] used Er:YAG to remove different ceramic full crowns bonded to human molars and showed that lithium disilicate debonding time was significantly lower than that for CAD Zirconia crowns.

In the other hand, this was disagreement with Alikhasi M. et al in 2019 [18] who showed much higher debonding time of lithium disilicate, which may be due to different size of samples and different laser parameters used. Another study by Morford et al in 2011, showed that debonding of full lithium disilicate veneers bonded to enamel using Er:YAG laser needed much higher than shown in this study, this may be due using different type of laser, different samples measurements and bonding to enamel rather than dentin [7].

Limitations of this study were using one type of laser with one set of parameters, using one type of resin cement; added to that samples were not full crown contour.

CONCLUSION

Under the limitation of this study, these conclusions could be drawn:

1- The Ultra translucent zirconia and Lithium disilicate were debonded from dentin using Er,Cr:YSGG laser.

2- Er,Cr:YSGG laser debonding of lithium disilicate consumes much less time than that for ultra-translucent zirconia.

3- Destruction of hybrid ceramics when it was exposed to Er,Cr:YSGG laser to debond it from dentin.

Clinical recommendation

Using Er,Cr:YSGG laser for deboning resin infiltrated hybrid-ceramics is not recommended as it will subjected to sever destruction

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