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CO_2 and Er,Cr:YSGG Laser Applications in Debonding Ceramic Materials: An in Vitro Study

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Abstract **Introduction:** The aim of this study is to measure the strength needed to debond ceramic cylinders by using CO_2 and Er,Cr:YSGG lasers. **Materials and methods:** The in vitro experiment consists of 60 human teeth divided in 3 groups: Group 1 control, Group 2 with 3 seconds application of CO_2 laser, and Group 3 with 5 seconds application of Er,Cr:YSGG laser. The 3mmx3mm cylinders are made with E-max Press pressed ceramic and are cemented to the teeth with Relyx®. After the laser application on the samples, a Shear Bond Tester device was used to measure the shear strength. **Results:** Significant differences are found between the Group 1 control and the two treated with laser ($p<0.001$). **Conclusion:** The use of CO_2 and Er,Cr:YSGG lasers can be considered as a valid and safe method of ceramic restoration debonding. Further studies are necessary to evaluate different currents, the use water spray and different debonding times.

Keywords CO_2 Laser, Er,Cr:YSGG, Debond Ceramic, Lithium Disilicato, Oral Laser Applications

1. Introduction

Many articles have described the diverse applications of lasers in Dentistry [1,2], amongst them, the use of CO_2 and Er,Cr:YSGG lasers to soften the resin based cements. The purpose of this study is to find out more about the utility of these lasers to debond fixed ceramic restorations.

Most times, such circumstances as dental decay, pain, sensitivity, lack of aesthetics, pushes the dental professionals to remove restorations. It is necessary to cut the crown/veneer or even drill it completely given the complexity of debonding them, and these procedures will not allow the restorations to be used again, and a new one must be done. Therefore it is interesting to study debonding options without the harming or the teeth neither the restorations. In 1965 Zach and Cohen [3] experimented with Erbium lasers in monkeys teeth, and determined that the threshold increase of temperature to harm the pulp in an irreversible way is 5,5ºC. Later in 1992 Strobl, Tocchio et al. made a study with orthodontic brackets, which they could debond with lasers using less strength and without exceeding the threshold temperature [4, 5, 6]. More research was done with CO_2 and Er,Cr:YSGG; it showed that the increase of temperature generated on determined wavelengths, >0.1ºC, is not harmful.

All the cements used on the former articles are resin based, the polymerization contraction is between 2.6-5.7%, and over time compromises the seal, resulting in future micro leakage, marginal fractures or coloration changes that will require the restoration replacement.

The laser light must penetrate through the ceramic to get to the resin and make its effect; the ceramic materials do transmit the light, but restorations with metal do not, therefore they are out of this study.

In this study the materials to study are ceramics cemented with resin cements (such as Relyx® or Speed®).

Our hypothesis is that it is possible to debond ceramic crowns and veneers cemented with resin cements using CO_2 and ER,Cr:YSGG lasers. The aim of this study is to measure the strength (in Newtons) needed to debond 3mmx3mm lithium disilicate cylinders using both types of lasers, and evaluate if its practicality can substitute, in a future, the present debonding techniques.

2. Materials and Methods

The design consists of three groups to compare the shear strength needed to debond the ceramic samples using two types of laser.

Treatment allocation was performed using random number tables. The sample size for each group was 20 samples and has been calculated assuming unknown variances, standardized differences 1.5, alpha risk of 1.5% and a minimum power for each multiple comparison of 80%. Group 1 (control) is not subject to any laser irradiation, Group 2 is irradiated with CO_2 laser and Group 3 with laser Er,Cr: YSGG.

The samples are 60 human teeth hydrated with distilled water. Later, the teeth are drilled to expose the dentin and placed in a 1mm height metallic matrix filled with type IV cast.

In the lab, 3mm diameter was sprues are used to elaborate the E-max Press ceramic (Ivoclar Vivadent, Schaan, Liechtenstein, n.S06667, A2 LT). Once we obtain long ceramic cylinders, a diamond disc is used to cut them in 3mm height samples. To proceed the cementation, the dentin teeth surfaces are etched with orthophosphoric acid 37% for 15 seconds, washed with water and dried. Finally the ceramic discs are cemented with the self-adhesive cement Relyx®Unicem 2 (automix) and polymerized for 60 seconds. Should all the ready samples be placed in a container filled with distilled water for 48 hours with a temperature regulator to keep the water at 37ºC. (Figure 1)

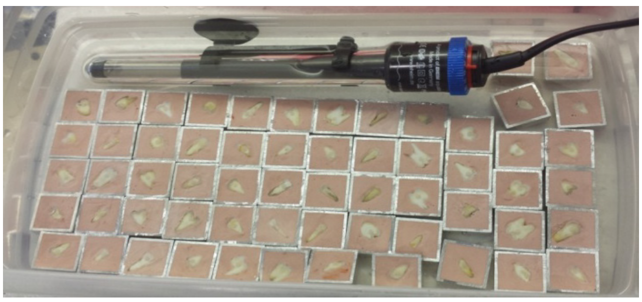

Figure 1. Samples stored in distilled water with temperature regulator

Group 2: The samples were irradiated with CO_2 laser (10600nm) Sharplan 1020 (Sharplan, Yokneam, Israel) 3W in continuous mode (cw), 1mm diameter spot, power density of 375W/cm^2, for 3 seconds and the tip perpendicular to the ceramic surface, 1 mm distance. (Figure 2)

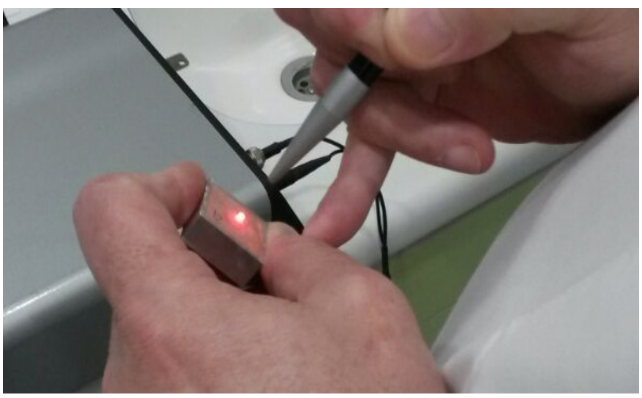

Figure 2. Sample being irradiated with Er,Cr:YSGG

Group 3: Samples irradiated with Er,Cr:YSGG (2780nm) Waterlase iPlus (Biolase, Irvine , USA) MZ10-6mm tip, 40Hz, 4W, 100 mJpps, 1 mm diameter spot and 12,5 J/cm^2 per pulse, for 5 seconds. In both groups the irradiation has not been refrigerated with water spray. (Figure 3)

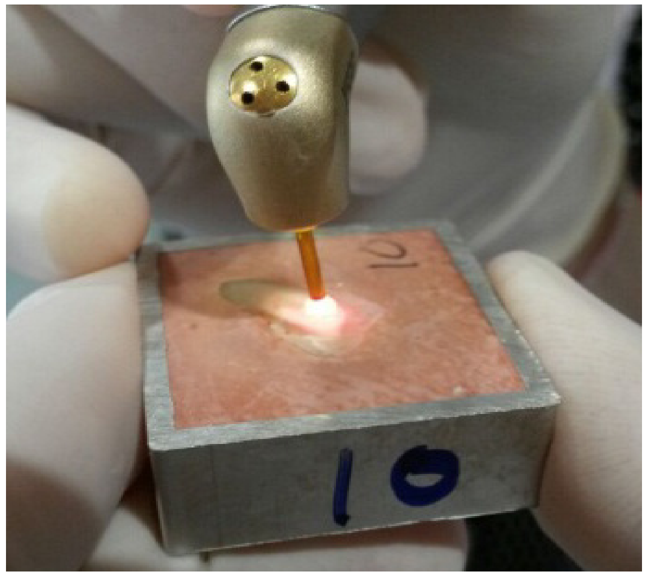

Figure 3. Sample irradiated with CO_2 laser

In each laser were selected power densities (CO_2) and fluences (Er,Cr:YSGG) that would not damage the surface of the ceramic. Therefore, the Er,Cr:YSGG was used without the water spray, as the micro explosions produced by the absorption with water could damage the ceramic surface.

Both units were calibrated before radiation, with a Gentec-EO Power Meter Master (Gentec-EO, Quebec, Canada) with the devices adjusted for each wavelength.

Resistance against shear forces was evaluated with a special device for this type of studies, Bisco Bond Shear Tester (BISCO Inc., Schaumburg, USA) (Figure 4), where the values of the forces required for debonding were registered from each of the samples, measured in Newtons. Randomization tables were used to establish the order of processing of the samples.

Figure 4. Sample being tested in the Bisco Bond Shear Tester

The qualitative variables were described by calculating the mean, median, standard deviation, maximum and minimum. The qualitative variables were described using frequency tables. The variable force (Nw) to debond is shown using box plots. Comparisos of debonding strength between groups was done using the test Mann-Whitney with Bonferroni correction. The number of lesions in each treatment was compared using the chi-square test.

The results have been digitized in an Excel spreadsheet and analyzed using SPSS statistical program vs 21. Sample sizes were calculated with 3.1 Epidat program. The hypothesis tests were performed with alpha risk of 5%.

Disability criteria: samples with spontaneous debonding had to be rejected (n = 2).

3. Results

The total number of analyzed samples is n = 58. In Group 1, 2 samples are removed to collect disability criteria (n = 18), Group 2 and Group 3 are n = 20. (Table1)

In Group 1 the samples required from 4,4N to 35,8N shear bond strength to separate them from the tooth.

In Group 2 (CO_2) 16 samples got detached from the tooth, that is to say 0 N of shear bond strength were required to separate the ceramic from the tooth, and the other 4 obtained shear bond strength values from 3,2N to 10.7N.

In Group 3 (Er,Cr:YSGG) the number of detached samples was 11, and the range of shear bond strength values to detach the remaining 9 samples was from 3,6N to 16,3N. (Figure 5)

Table 2 and Figure 5 describe and illustrate debonding force variable according to the treatments. The figure 5 shows that the CO_2 laser treated group obtains lower debonding force values compared with groups control and Er,Cr:YSGG, therefore it suggests.

Table 1. Summary of total number of samples

Group	Samples				
	Successful		Failed		Total
	N	%	N	%	N
1	18	90,0%	2	10,0%	20
2	20	100,0%	0	0,0%	20
3	20	100,0%	0	0,0%	20

Table 2. Descriptive parameters of the results using SPSS statistical program vs 21

	Group		Statistic	Standard error
Shear Bond Strength	1	Mean	13,1167	2,11964
		Median	9,7000	
		Standard deviation	8,99289	
		Min.	4,40	
		Max.	35,30	
		Interquantile range	12,05	
	2	Mean	1,1300	,61096
		Median	,0000	
		Standard deviation	2,73228	
		Min.	,00	
		Max.	10,70	
		Interquartile range	,00	
	3	Mean	3,6945	1,33322
		Median	,0000	
		Standard deviation	5,96235	
		Min.	,00	
		Max.	21,00	
		Interquartile range	6,03	

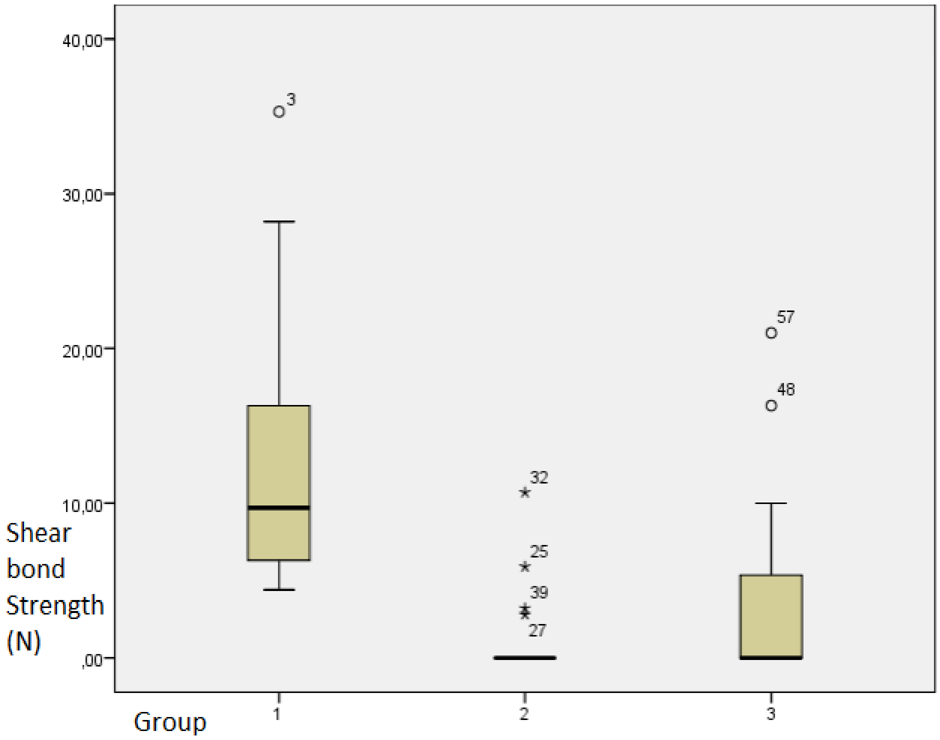

Figure 5. Box plot shows the range on Shear bond strength needed for each group

Comparing the shear bond strength values of the 3 Groups with non-parametric tests, in the Kruskal-Wallis test p= 0,0001. Therefore it shows differences between the results of the 3 groups.

Mann-Whitney and the Bonferroni correction test results indicate that there are significant differences between the control group and the groups treated with laser (p <0.001). While shows no significant differences between the two groups treated with lasers (p = 0.15).

In some samples it can be seen that the laser has caused a brown coloration in the dentin, possibly generated by the increased temperature or carbonization of the resin, so this information is incorporated as a new variable to analyze. In Group 2, the 60% of samples (12/20) have this coloration, while in Group 3 it was only found in 25% of samples (5/20). Fisher's exact test indicates a difference of p = 0.053. It can be interpreted that there are no significant due to lack of power and due to a limitation imposed by the number of the samples.

4. Discussion

The results obtained in this in vitro study support the hypothesis that it is possible to debond ceramic materials with these 2 types of lasers. 2014 Sari et al. published a study about the absorption and transmission of the Er:-YAG laser applied for 5 seconds through different types of ceramics [7]. The E-max press had the higher transmittance value. This study samples were between 0.5mm and 1 mm and holds that as this thickness increase more, the laser transmission decreases. Our samples have larger sizes, 3mm, and the results show that transmission is enough to soften the cement.

Our samples have a 3mm diameter surface and were irradiated Er,Cr:YSGG laser for 5 seconds, a study of Morford and associates in 2011 used Er,Cr:YSGG 2.780nm to debond veneers and achieved it after a period of irradiation between 100 and 42 seconds[8]. The differences between the times are due to the extension of the specimens.

Nalbantgil et al. [9] studied the different application times in the use of Er:YAG laser, the different debonding shear strength needed and measured the increasing pulp temperature. 80 samples were used to debond ceramic brackets, adhesive composite Transbond XT was used to cement them. The samples were divided in groups: Group 1 with 3 seconds of laser application (Er:YAG power 4.2W, wavelength 2,940nm, 140mJ, 30Hz, spot 1mm diameter), Group 2 with 6 seconds, Group 3 with 9 seconds and Group 4 as control. Significant differences were found between the control group and the ones with laser application. The necessary strength needed to debond the samples decreased as the time of exposure increases. The pulp temperature rise up to 4,59ºC in the 9 seconds application. However, these values are still safe since they are below the threshold of 5.5ºC pulp damage. The study concludes that the 3 groups are valid for debond the braces, as the exposure time is increased, the pulp temperature is increased, therefore they propose that the safest method is to irradiate for 6 seconds.

Iseri et al. [10] performed a study similar to ours. 60 bovine teeth were divided in a Group control and Group irradiated with Er:YAG (2,940nm wavelength, Power 5W [50Hz, 100 mJ per pulse]) for 9 seconds without water spray. 0.7mmx0.5mm IPS Empress Samples were made and cemented to the teeth with the resin cement Variolink II. After the exposure, a device is used to measure the shear force needed to debond the samples and the results showed significant differences between the laser group and the control group. The article concludes that the use of Er: YAG laser is useful and safe for debond porcelain veneers.

Sari et al. [11] performed an interesting study comparing the transmission of Er:YAG's light (500mJ, 2Hz, 1W) through 5 types of common restorative materials (feldspatic ceramic, lithium disilicate, monolithic zirconia, zirconium with sintered ceramic and alumina ceramic). 0.5mm and 1mm thickness discs were made with every material. The samples were irradiated and 10 measurements were taken from each sample. The material showing higher rates of laser transmission was the lithium disilicate with 0.5mm thickness (88%), and the lowest transmission rates were found in the 1mm thickness feldspatic ceramic. The study concludes that the laser transmission decreases as the thickness of the restorations increases, and the best material to transmit the laser is lithium disilicate.

Many studies also report the appearance of carbonized resin areas in the enamel/dentin and in the ceramic [12, 13, 14], compatible with the ones that we obtain and named discoloration variable, probably caused by not using irrigation during the irradiation. Mimura et al. [15] describes it as MMA resin remaining on the tooth surface after debonding with CO_2.

Van as [16] performed a study in 2012 with Erbium lasers, using irradiation, to debond ceramic veneers from in vivo human teeth and obtaining satisfactory results where the veneers were debonded without breaking or harming the teeth. One case presented brown colorations that the author describes as non-polymerized properly resin in the surface of the dentin, but also concluded that more studies testing the use of higher laser energy and not using irrigation are necessary.

5. Conclusions

Given the limitations of this study, we can conclude that both CO_2 and Er,Cr:YSGG lasers are a valid technique to debond ceramic restorations when resin cement Relyx® is used. With Er,Cr:YSGG it is required less than 5N shear force to separate the ceramic from the tooth. The appearance of changes of coloration (brown) are also observed particularly when the CO_2 is used, without irrigation, which could lead to a safer use of the Er,Cr:YSGG. More studies are needed to compare different wavelengths, combined with the use of irrigation, and study of the involvement of the dentin under light microscope to establish an appropriate pattern of debonding.

REFERENCES

[1] España-Tost Antonio Jesús, Arnabat-Domínguez José, Berini-Aytés Leonardo, Gay-Escoda Cosme. Aplicaciones del láser en Odontología. RCOE. 2004 Oct; 9(5): 497-511

[2] Masahiro Iijima, Yoshitaka Yasuda, Takeshi Muguruma, and Itaru Mizoguchi (2010) Effects of CO2 laser debonding of a ceramic bracket on the mechanical properties of enamel. The Angle Orthodontist: November 2010, Vol. 80, No. 6, pp. 1029-1035.

[3] Zach L, Cohen G. Pulp response to externally applied heat. Oral Surg Oral Med Oral Pathol. 1965;19:515-30

[4] FreitasPatrícia Moreira de, Soares-Geraldo Débora, Biella-Silva Ana Cristina, Silva Amanda Verna, Silveira Bruno Lopes da, Eduardo Carlos de Paula. Intrapupal temperature variation during Er,Cr: YSGG enamel irradiation on carries prevention. J. Appl. Oral Sci

[5] Strobl K, Bahns TL, Willham L, Bishara SE, Stwalley WC. Laser-aided debonding of otrthdontic ceramic brackets. Am J Orthod Dentofac Orthop. 1992;101:152-8

[6] Tocchio RM, Williams PT, Mayer FJ, Standing KG. Laser debonding of ceramic orthodontic brackets. Am J Orthod Dentofac Orthop. 1993;103:155-62

[7] Tugrul Sari, Ilkin Tuncel, Aslihan Usumez and Norbert Gutknecht. Transmission of Er:YAG Laser Through Different Dental Ceramics. Photomedicine and Laser Surgery Volume 32, Number 1, 2014

[8] Morford CK, Buu NCH, Rechmann BMT, Finzen FC, Sharma AB, Rechmann P. Er:YAG Laser Debonding of Porcelain Veneers. Lasers Surg Med. 2011;43:965-7

[9] Nalbantgil D, Oztoprak MO, Tozlu M, Arun T. Effects of different application durations of ER:YAG laser on intrapulpal temperature change during debonding. Lasers Med Sci 2011; 26: 735-40.

[10] UfukIseri, Mehmet Oguz Oztoprak, Zeynep Ozkurt, Ender Kazazoglu, and TulinArun. Effect of Er:YAG laser on debonding strength of laminate veneers. Eur J Dent. 2014 Jan-Mar; 8(1): 58–62.

[11] Tugrul Sari, Ilkin Tuncel, Aslihan Usumez, and Norbert Gutknecht. Transmission of Er:YAG Laser Through Different Dental Ceramics. Photomedicine and Laser Surgery Volume 32, Number 1, 2014

[12] Ekworapoj P, Sidhu SK. Effect of different power parameters of Er,Cr:YSGG laser on human dentine. Lasers Med Sci. 2007;22:175-82

[13] Fried D, Ashouri N, Breunig S, Shori R. Mechanism of Water Augmentation During IR Laser Ablation of Dental Enamel. Lasers Surg Med. 2002; 31: 186-93.

[14] Hossain M, Nakamura Y, Yamada Y, Kimura Y, Matsumoto N, Matsumoto K. Effects of Er,Cr:YSGG Laser Irradiation in Human Enamel and Dentin: Ablation and Morphological Studies. J Laser Surg Med. 1999;17(4):155-59

[15] Mimura, Hiroshi et al. Comparison of different bonding materials for laser debonding. American Journal of

Orthodontics and Dentofacial Orthopedics, September 1995, Volume 108 , Issue 3, 267 - 273

[16] Glenn van Ass. Laser removal of porcelain veneers. Dentistry today [updated 14 Sep 2012, access: Jan 15 2016] Available in:http://www.dentistrytoday.com/technology/lasers/8090-laser-removal-of-porcelain-veneers.