IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 19, Issue 6 Ser.5 (June. 2020), PP 38-42
www.iosrjournals.org

The effect of Er,Cr: YSGG Laser Surface Treatment on Shear Bond Strength of Resin Cement to Zirconia Ceramic

Recep Kara[1]
[1](Department of Prosthodontics, Faculty of Dentistry/ Istanbul AydınUniversity, Turkey)

Abstract:
Background: *The study purposed to evaluate the effect of Er,Cr: YSGG Lasersurface treatment method on the shear bond strength (SBS) of resin cement to zirconia ceramic.*
Materials and Methods: *Fifty composites and zirconia samples (4mm diameter and 4mm height) were prepared for each material. According to surface treatments, sintered zirconia samples were divided into five groups (n=10) as no treatment (NT; control), sandblasting (SB), laser treatment (LT), silica coating (CT), and 9.5% hydrofluoric acid-etching (HF). Composite cylinders resin samples bonded zirconia samples were with resin cement (Panavia F2.0; Kurayay, Okuyama, Tokyo, Japan). The shear bond strength test was performed with a universal test machine for each sample.Data were analyzed with one-way ANOVA and post hoc test (Tukey's). A statistically significant difference was found between the groups.*
Results:*The highest value was in the laser abrasion group (32.43 ± 3.72), this group was not statistically significant from the silica coating group (28.29 ± 3.16). The sandblasting group (20.27 ± 2.33) and the acid etching group (11.58 ± 1.57) were also statistically different from other groups.*
Conclusion:Er,Cr : YSGG laser and silica coating treatments can be an alternative method to enhance the bond of resin cement to dental zirconia ceramic.*
Key Word: *Shear Bond Strength, Zirconia, Silica Coating, Sandblasting, Er,Cr : YSGG Laser, Hydrofluoric Acid-etching*

Date of Submission: 26-05-2020 Date of Acceptance: 13-06-2020

I. Introduction

All-ceramic restorations are the most preferred restorations because they are aesthetically similar to natural teeth. The use of zirconia (ZrO_2) ceramics has increased due to their high biomechanical and aesthetic properties in their production (1–3). The crystal structure of the zirconia, which is monoclinic at room temperature, varies depending on the temperature and pressure when it is in the tetragonal phase at 1170 ° C and transforms into the cubic phase at 2370 °C. Stresses caused by volumetric expansion when heated to about 1700 ° C can cause cracks in the ceramic structure when cooled to room temperature. Yttrium oxide is added to stabilize the structure and maintain properties. Yttrium oxide infiltrated zirconia ceramics (Y-TZP) have higher mechanical properties than other dental ceramics (4,5).

Treatment should be made on the zirconia surface for an acceptable adhesion to the tooth. Acid etching is not suitable since there is no glass matrix in the structure of zirconia. Lots of research has been done to increase the surface roughness and chemical bonding of zirconium ceramics. Various surface preparation methods are available to increase adhesion, such as the use of organofunctional silanes (6), the use of phosphate-modified monomer resin cement (7), the Si vapour phase deposition method (8), the use of zirconate bond primers (9), the selective infiltration etching procedure (10), the tetraethoxysilane flame treatment device (8), air abrasion (11) and laser irradiation (12).

Laser surface treatments have been researched by many researchers and found safe and easy to apply. Carbon dioxide lasers, erbium lasers (Er: YAG laser "erbium: yttrium aluminum garnet laser"; Er,Cr: YSGG laser "erbium, chromium: yttrium scandium gallium garnet laser"), Nd: YAG lasers (neodymium: yttrium aluminum garnet lasers) have been used widely (11,12).

The effect of different surface treatments, including laser treatments, on resin cement's bonding power to ceramic restoration, has been evaluated in many studies, but the number of studies examining the effect of Er,Cr: YSGG laser surface treatment applied to Y-TZP ceramics is limited. This study was performed to compare the effect of Er,Cr: YSGG laser surface treatment on the bond strength of zirconia ceramics with other surface treatments.

II. Material And Methods

Fifty zirconia ceramic discs (4mmx4mm) were milled with trepan bur (Meisinger; L.L.C, US) from a sintered block (Zenostar, Wieland Dental; Pforzheim, Germany)(Figure 1A). PVC (polyvinylchloride) mold with 4mm thickness and 4mm internal space was used in the production of composite samples (Figure 1B). An insulator (Vasline, petroleum jelly, Mainland, China) was applied to the internal cavity walls of the PVC mold in order not to stick the composite resin (Estelite Sigma Quick, Tokuyama Dental, Tokyo, Japan). All samples diameters (4 ± 0.2mm) were measured with a digital caliper (DC 500-144B, Mitutoyo, São Paulo, Brazil). Polished zirconia samples were divided into five groups (n=10) according to the treatment used.

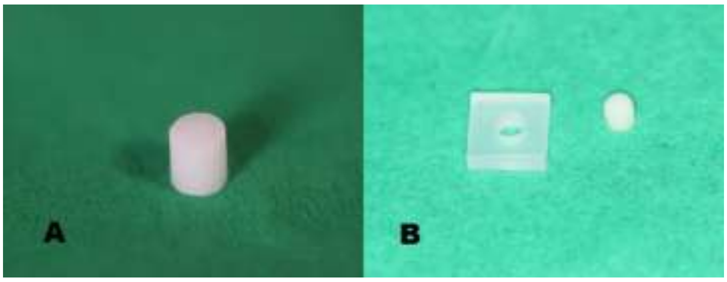

Figure 1. A: Zirconia sample; B: Composite sample

Following all five surface treatment methods, treated samples were ultrasonically cleaned (Biosonic UC50, Coltene Whaledent, US) for 3 min. in distilled water, and dried. The composite discs bonded to zirconia samples with monomer-phosphate-based self-adhesive resin cement (Panavia F2.0; Kurayay, Okuyama, Tokyo, Japan) under 2N constant load in low force universal testing system (Instron 3400; Instron, MA, US) and for 20 s. under the manufacturer's recommendations. Oxygene inhibiting gel applied (Oxyguard II, Kuraray, Tokyo, Japan) on the surfaces, and an LED light-curing unit (Bluephase, Ivoclar Vivadent AG, Liechtenstein) was applied for 20 s. for polymerization. The bonded samples stored in distilled water at 37 °C for 24 hours before shear bond tests.

Composite resin bonded zirconia samples were embedded in acrylic. The embedded samples in acrylic were placed in the test machine to apply the force of the mono-inclined chisel tip to the ceramic-composite interface. The SBS was tested in a universal testing machine (Instron 3400; Instron, MA, US) at a cross-head speed of 1 mm/min until debond occurred (Figure 2A). Maximum load failure the samples were recorded in Newton, and SBS values were calculated in units of megapascal (Mpa).

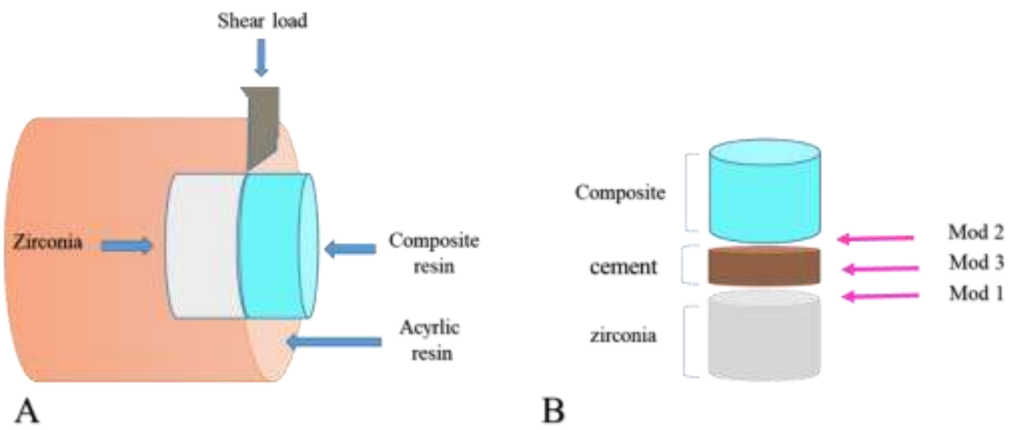

Figure 2. A: Shear bond strength test, B: Adhesive failure mode

Statistical analysis

Statistical analysis was carried out in SPSS 22 (SPSS Inc.,Chicago, IL, US). Data were analyzed with ANOVA and post hoc test (Tukey's) according to p = 0.01 significance level.

III. Result

Statistical differences were found between the groups. The average shear strength of the groups is shown in Figure 3. The shear bond strength was 28.29 ± 3.16 MPa for the silica coating group, and 32.43 ± 3.72 MPa for the Er,Cr: YSGGgroup.The SBS value of the LT and SC groups was statistically similar. SBS values of other groups were different from each other. The order of SBS values was as follows (LT = SC>SB> HF> NT).

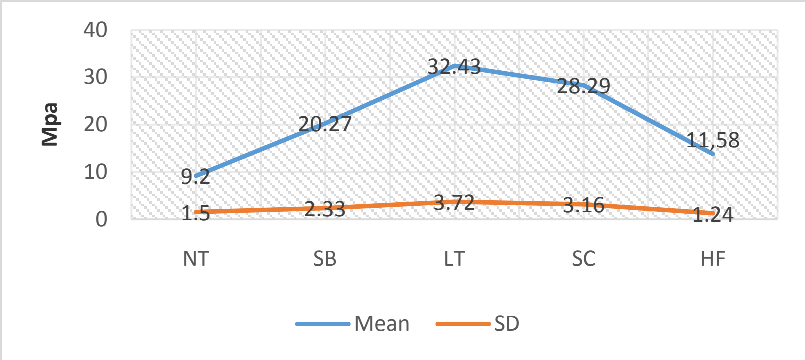

Figure 3. Shear bond strength values of groups

Microscopic evaluation of surfaces

Following SBS tests, all fracture surfaces were examined with SEM microscope (Hitachi S-3500N, Hitachi High-Technologies, Tokyo, Japan) to assess the surface details. Surface changes and error modes were evaluated. Failure types were classified into three groups.

Mode 1: adhesive (between resin and zirconia)

Mode 2: adhesive (between resin and composite)

Mode 3: mixed failure (includes both of them in the same sample)

The SBS between zirconia and composite resin has failed. Adhesive failure of the groups between zirconia and the composite resin interface are shown in Table 1.

Table 1.

Groups	Adhesive Failure Mode					Total
	NT	SB	LT	SC	HF	
Mode 1	10	4	8	1	10	10
Mode 2	-	2	1	5	-	10
Mode 3	-	4	1	4	.	10

In the microscopic evaluation of the SB group, it showed a rough surface with irregularities and consistent presence of shallow pits. In the laser application group, inhomogeneous surface roughening of the surface was observed with micro-cracks and micro retentive grooves. Irregularly shallow pits were observed in the HF group. Zirconia surfaces treated with silica coating showed only minor changes in the tissue. Cement residues can be detected on the zirconia surface in CT and SB groups, while entirely separate from the ceramic surface has occurred in NT and HF groups.

IV. Discussion

Milled zirconia surfaces have a smooth and regular crystalline flat structure. Sandblasting is a preferred surface treatment method for high resistance ceramics. Surface roughening methods increase surface energy and wettability. This process provides increased bonding strength resistance.

The Cojet system consists of silica-modified Al_2O_3 particles that can create surface roughness on the scraper. There is a tribochemical reaction, a high-temperature contact area is formed, and then a silica coating is made, which can react with silane agents to promote resin bonding (13). Microscopic analysis shows a thin micro-retentive layer that enhances the chemical and mechanical bond strength to the resin (14). The silane bonding agent cross-links with methacrylate groups to form a chemical bond to the resins and also increases surface energy, thereby increasing wettability to the resins (15). This adhesive mechanism is an interesting choice for conditioning poly-crystal ceramics, taking into account the high bond strength values observed for the CT-treated group (16). In this silica coating procedure, the effect of particle size and application time should also be assessed, as possible further aggressive applications may increase microcrack formation and thus affect the adhesive bond quality (17).

In this study, silica coating group Al_2O_3 bonded with monomer-phosphate-based (MDP) resin cement exhibited high SBS compared to the SB group and HF group. Bottino. et al. (18) and Petrauskas. et al. (19) found that the triborochemical method improved adhesion strength when used with an MDP containing resin cement compared to the use of sandblasting wear. These results are consistent with the results of this study.In contrast, another study has found that blasting with a phosphate monomer resin cement produces a more suitable durable bond than those treated with silica coating and bonded with a Bis-GMA primer resin (20). Therefore, it can be a good alternative to use a tribochemical system combined with MDP resin cement for the cementation of zirconia ceramics.

HF treatment showed SBS close to the group with almost sandblasted treatment in this study. Although HF acid gel works well in terms of getting high bond strength on glass matrix ceramics, the results are poor when used for reinforced ceramics (21). Sriamporn et al. reported that HF concentration levels, application times, and the temperature of the acid solution affect the reaction rate leading to morphological changes (22). Previous studies of zirconia etching using etching times ranging from 1 to 12 minutes at room temperature and HF concentrations ranging from 4.5-38% showed that HF did not affect the zirconium surface (23). The results of these studies showed that HF had less effect on zirconium and concluded that HF could not react since zirconia ceramic is a glass-free material. The low SBS value for HF in this study may be due to the low concentration level and short application time.

Lasers have been used in clinics and laboratories for many years in dentistry. The first hard tissue lasers developed in the 1990s, and have been used in dental practice since 1997. These hard tissue lasers have dental tissue and bone preparation capacity in addition to soft tissue cutting (24). Nd: YAG, CO2, Er: YAG and Er,Cr: YSGG lasers are used in surface preparations, including zirconia. However, the effect of Er,Cr: YSGG lasers is less in the surface preparations of zirconia.

An in-vitro study found that Er, Cr: YSGG laser, and silica coating treatment increased bond strength between zirconia and resin cement.The previous studies of Akin et al., Paranhos et al., Ural et al. have proved that Nd: YAG, Er: YAG, CO2 lasers have better bond strength than the sandblasting group (3,25,26). These studies support the results of this study.Ghemi et al. And Zanjani et al. stated that the sandblasting group had better shear strength than the Er Cr: YSGG laser group (27). These results and the results of Cavalcanti et al and Foxton et al's previous studies are in contrast to the results of this study (5). The reason for these different results may be that the laser energy used is different. The cement used in this study is different from the cement used in the specified studies.Gokce et al. concluded that the 300 MJ, 20 Hz, and 6 W Er: YAG laser provides better bonding power than higher application energy parameters (11). Kursoğlu et al. performed surface treatments with Er,Cr: YSGG laser with 21, 300 MJ, 20 Hz and 1.5, 2.5, 6-watt energy, and found higher SBS for the 1.5 and 2.5 W groups (12). In this study, where energy parameters were set to 2W, 25Hz, 300 MJ depending on the studies stated, it was significantly higher than sandblasting.

This study does not include the effect of long-term storage and thermocycling. This study showed that zirconia ceramics increased SBS results for surface treatment with Er,Cr: YSGG lasers and silica coating.

V. Conclusion

According to the results of this in vitro study, the following results are indicated.
Silica coating treatment that improves the bond strength of resin cement to zirconia ceramic when using MDP based resin cement.Er,Cr: YSGG laser treatment method provides durable bond strength when the correct energy and time are applied and can be an alternative pretreatment to increase the bond strength of the resin cement.

References

[1]. Dilber E, Yavuz T, Kara HB, Ozturk AN. Comparison of the effects of surface treatments on roughness of two ceramic systems. Photomed Laser Surg. 2012;
[2]. Kirmali O, Akin H, Ozdemir AK. Shear bond strength of veneering ceramic to zirconia core after different surface treatments. Photomed Laser Surg. 2013;31(6):261–8.
[3]. Akin H, Ozkurt Z, Kirmali O, Kazazoglu E, Ozdemir AK. Shear bond strength of resin cement to zirconia ceramic after aluminum oxide sandblasting and various laser treatments. Photomed Laser Surg. 2011;29(12):797–802.
[4]. Cavalcanti AN, Foxton RM, Watson TF, Oliveira MT, Giannini M, Marchi GM. Y-TZP ceramics: Key concepts for clinical application. Operative Dentistry. 2009.
[5]. Cavalcanti AN, Pilecki P, Foxton RM, Watson TF, Oliveira MT, Gianinni M, et al. Evaluation of the surface roughness and morphologic features of Y-TZP ceramics after different surface treatments. Photomed Laser Surg. 2009;
[6]. Matinlinna JP, Lassila LVJ, Vallittu PK. Pilot evaluation of resin composite cement adhesion to zirconia using a novel silane system. Acta Odontol Scand. 2007;
[7]. Blatz MB, Sadan A, Kern M. Resin-ceramic bonding: A review of the literature. J Prosthet Dent. 2003;
[8]. Piascik JR, Swift EJ, Thompson JY, Grego S, Stoner BR. Surface modification for enhanced silanation of zirconia ceramics. Dent Mater. 2009;25(9):1116–21.
[9]. Yoshida K, Tsuo Y, Atsuta M. Bonding of dual-cured resin cement to zirconia ceramic using phosphate acid ester monomer and zirconate coupler. J Biomed Mater Res - Part B Appl Biomater. 2006;
[10]. Aboushelib MN, Kleverlaan CJ, Feilzer AJ. Selective infiltration-etching technique for a strong and durable bond of resin cements

to zirconia-based materials. J Prosthet Dent. 2007;
[11]. Liu D, Matinlinna JP, Tsoi JKH, Pow EHN, Miyazaki T, Shibata Y, et al. A new modified laser pretreatment for porcelain zirconia bonding. Dent Mater. 2013;
[12]. Aboushelib MN, Mirmohamadi H, Matinlinna JP, Kukk E, Ounsi HF, Salameh Z. Innovations in bonding to zirconia-based materials. Part II: Focusing on chemical interactions. Dent Mater. 2009;
[13]. Haselton DR, Diaz-Arnold AM, Dunne JT. Shear bond strengths of 2 intraoral porcelain repair systems to porcelain or metal substrates. J Prosthet Dent. 2001;86(5).
[14]. Valandro LF, Della Bona A, Bottino MA, Neisser MP. The effect of ceramic surface treatment on bonding to densely sintered alumina ceramic. J Prosthet Dent. 2005;93(3).
[15]. Liu D, Pow EHN, Tsoi JKH, Matinlinna JP. Evaluation of four surface coating treatments for resin to zirconia bonding. J Mech Behav Biomed Mater. 2014;32.
[16]. Galvão Ribeiro BR, Galvão Rabelo Caldas MR, Almeida AA, Fonseca RG, Adabo GL. Effect of surface treatments on repair with composite resin of a partially monoclinic phase transformed yttrium-stabilized tetragonal zirconia. J Prosthet Dent. 2018;119(2).
[17]. Kern M, Thompson VP. Sandblasting and silica coating of a glass-infiltrated alumina ceramic: Volume loss, morphology, and changes in the surface composition. J Prosthet Dent. 1994;71(5).
[18]. Amaral R, Özcan M, Bottino MA, Valandro LF. Microtensile bond strength of a resin cement to glass infiltrated zirconia-reinforced ceramic: The effect of surface conditioning. Dent Mater. 2006;22(3):283–90.
[19]. Petrauskas A, Novaes Olivieri K, Pupo Y, Berger G, Gonçalves Betiol E. Influence of different resin cements and surface treatments on microshear bond strength of zirconia-based ceramics. J Conserv Dent. 2018;21(2).
[20]. Kern M, Wegner SM. Bonding to zirconia ceramic: Adhesion methods and their durability. Dent Mater. 1998;14(1).
[21]. Tashkandi E. Effect of surface treatment on the micro-shear bond strength to zirconia. Saudi Dent J. 2009 Oct;21(3):113–6.
[22]. Sriamporn T, Thamrongananskul N, Busabok C, Poolthong S, Uo M, Tagami J. Dental zirconia can be etched by hydrofluoric acid. Dent Mater J. 2014;33(1).
[23]. Qeblawi DM, Muñoz CA, Brewer JD, Monaco EA. The effect of zirconia surface treatment on flexural strength and shear bond strength to a resin cement. J Prosthet Dent. 2010;103(4).
[24]. Cvikl B, Moser G, Wernisch J, Raabe M, Gruber R, Moritz A. The impact of Er,Cr:YSGG laser on the shear strength of the bond between dentin and ceramic is dependent on the adhesive material. Lasers Med Sci. 2012;
[25]. Motro PFK, Kursoglu P, Kazazoglu E. Effects of different surface treatments on stainability of ceramics. J Prosthet Dent. 2012;
[26]. Foxton RM, Cavalcanti AN, Nakajima M, Pilecki P, Sherriff M, Melo L, et al. Durability of resin cement bond to aluminium oxide and zirconia ceramics after air abrasion and laser treatment. J Prosthodont. 2011;
[27]. Ghasemi A, Kermanshah H, Ghavam M, Nateghifard A, Torabzadeh H, Nateghifard A, et al. Effect of Er,Cr: YSGG laser treatment on microshear bond strength of zirconia to resin cement before and after sintering. J Adhes Dent. 2014;

Recep Kara. "The effect of Er,Cr: YSGG LaserSurface Treatment on Shear Bond Strength of Resin Cement to Zirconia Ceramic." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 19(6), 2020, pp. 38-42.