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The effect of Er, Cr: YSGG Laser Surface Treatment and Sandblasting on Shear Bond Strength of Zirconia Ceramics- in Vitro Study

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Introduction

All ceramic restorations are the most widely used esthetic restorations to simulate natural dentition. Among these the use of zirconia (ZrO2) ceramics increased due to its high flexural strength, transformation toughness, white color, chemical and structural stability.[1-4]Zirconia exists in many crystalline structures depending on temperature and pressure. It is monoclinical at room temperature and transforms to tetragonal form at 1170 ^{0}C and to cubic phase at 2370^{0}C. Stresses generated due to vast volumetric expansion on heating to about 1700 ^{0}C can lead to breakage of ceramic on cooling to room temperature. yittrium oxide is added to stabilize zirconia and maintain its properties. These yittrium oxide stabilized zirconia ceramics(Y-TZP) has superior mechanical properities than all other dental ceramics.[2,5,6,7]

Zirconia surface must be prepared to achieve reliable bonding to teeth. The absence of glassy matrix makes zirconia chemically inert and not amenable to acid etching. A lot of research was conducted to increase surface roughness and chemical bonding with zirconia ceramics. Various methods to improve adhesion include , air abrasion,[8-12] use of phosphate modified monomer resin cement,[9,13,14] use of zirconate coupler primers,[15] use of organofunctional silanes,[16,17] tetraethoxysilane flame – treat device, the Si vapour phase deposition method,[18] selective infiltration etching procedure [19,20,21] and laser irradiation.[1,3-7,21-27]

Laser surface treatment for surface modification of ceramics was proposed and investigated by various authors. This method is considered relatively safe and easy. Lasers include neodymium: yittrium aluminium garnet (Nd:YAG), carbon dioxide lasers, erbium yttrium aluminium garnet (Er:YAG), erbium ,chromium: yttrium, scandium, gallium, garnet(Er,Cr:YSGG) have been used.[1,3-7,21-28]

Many studies evaluated the effect of different surface treatments including laser treatments on the bond strength

of resin cement to ceramic restoration, but the effect of Er,Cr:YSGG laser surface treatment of Y-TZP ceramics is very limited. This study was done to determine the effect of Er,Cr:YSGG laser surface treatment on shear bond strength of zirconia ceramics.

Materials and Methods

Forty zirconia ceramic discs (Zenostar, Wieland Dental; Pforzheim, Germany) of ∞5mm x 5mm height size were milled and sintered according to manufacturer's instructions. They were divided into sand blasted group and laser treated group of 20 each. Sand blasting was performed with 50 µm Al_2O_3 particles at a 2.5 bar pressure for 15 seconds at a distance of 10mm. Laser surface treatment was done with Er,Cr:YSGG laser(Waterlase MD, Biolase; California, USA) with a 2.78 µm wavelength,2 watts, 300mJ energy intensity, 25 hertz pulse. The optical fiber of the laser (400 µm diameter, 4 mm length) was aligned perpendicular to each specimen at a distance of 1 mm and moved manually in a sweeping fashion over the entire area during a 20 seconds exposure period. All the specimens were cleaned ultrasonically for 180 seconds and air dried. Forty molar teeth were embedded in the resin blocks and occlusal surface was flattened to expose dentin. All the specimens of two groups were luted to the tooth surface with resin cement (Relyx U 200, 3M ESPE; Seefeld, Germany) following manufacturer recommendations under finger pressure. All the specimens were stored in distilled water at 37 ^{0}C for 24 hours. Shear bond strength was tested with universal testing machine (UTM:Minitech,Dak systems inc; Mumbai,India) at a cross head speed of 1mm per minute. One specimen from each group was evaluated under SEM (Hitachi S3770;Tokyo, Japan) to assess the surface details.

Results

Statistical analysis was done with paired t test. p value less than 0.001 were considered statistically significant.

Table 1 shows the mean shear bond strength of sand blasted group and laser treated group.

Sand blasted group showed shear bond strength of 1.3975 MPa and Er,Cr:YSGG group showed 3.5075 MPa. Shear bond strength values of laser treated group were significantly higher than sand blasted group.

SEM evaluation of sand blasted group (Fig.1) showed uniform rough surface with uniform presence of irregularities and shallow pits. Er,Cr:YSGG laser irradiation group(Fig.2) showed formation of inhomogenous roughening of surface with micro cracks and micro retentive grooves.

Discussion

Lasers have been in use for clinical and laboratory purposes in dentistry for many years. Hard tissue lasers, first developed in the 1990s, and came to the dental practice since 1997. These hard tissue lasers have the capacity to prepare enamel, dentin, caries, cementum, and bone in addition to cutting soft tissue.[28] Lasers used in surface treatment of zirconia include Nd:YAG , CO2, Er:YAG and Er,Cr:YSGG . The effect of Er,Cr:YSGG lasers for surface treatment of zirconia is limited.

The present study was done to evaluate the effect of Er,Cr:YSGG laser and air particle abrasion on bond strength of zirconia to 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.[3,22,24] These studies are supporting the results of the present study in which Er,Cr:YSGG laser group(3.5 MPa) has better bond strength than the sand blasting group (1.4 MPa).

On the contrary recently published studies by Ghemi et al and Zanjani et al have shown better shear bond strength for sand blasting group than Er,Cr:YSGG laser group.[29,30] The results of these studies and previous studies by Cavalcanti et al and Foxton et al are on the opposite side

of the present study results.[6,23] The reasons might be the energy parameters and the resin cement employed in those studies was different from the current study.

Gokce et al [26] concluded through their study that Er:YAG laser of 300 mJ, 20 Hz and 6 W yielded better bond strength than higher energy parameters. Kursoglu et al [21] done surface treatments with Er,Cr:YSGG laser of 300 mJ, 20 Hz and 1.5, 2.5, 6 watts energy settings and found significant higher shear bond strengths for 1.5 and 2.5 W groups. Based on the above studies the energy parameters in the present study were set at 2W, 25Hz, 300mJ. With these energy parameters the shear bond strength of zirconia ceramics was significantly higher than the sandblasting.

The shear bond strength test was preferred because of ease of testing. The limitations of the present study include the effect of long term storage and thermo cycling has on shear bond strength of the zirconia ceramics to resin cement. The present study has shown encouraging results for surface treatment of zirconia ceramics with Er,Cr:YSGG lasers.

Conclusion

Er,Cr:YSGG laser surface treatment demonstrated higher shear bond strength of resin cement to zirconia ceramics than sand blasting. Within the limitations of the present study, this in vitro study has to be done on larger sample size and randomized controlled trials need to be evaluated before corroboration of these results into the clinical scenario.

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Legends Figure and Table

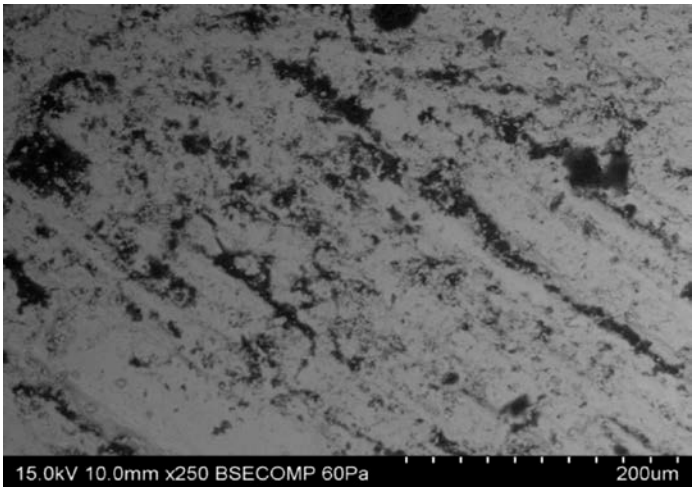

Figure1. Scanning electron microscope image of laser treated surface (x 250 magnification)

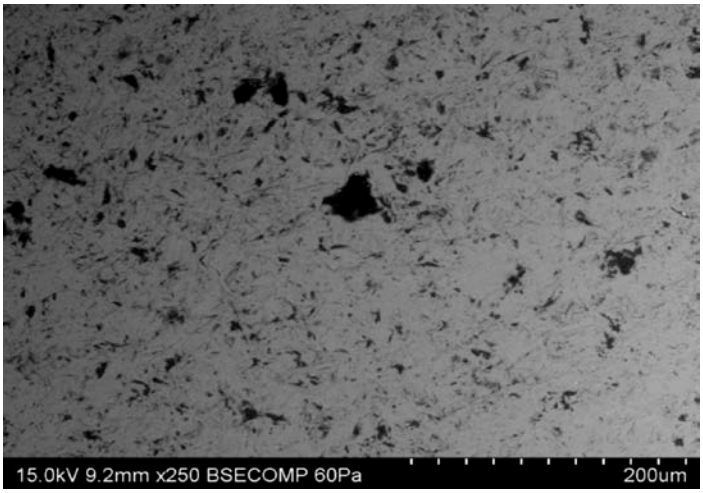

Figure2. Scanning electron microscope image of sand blasted surface (x 250 magnification

Tables

Table1. Mean shear bond strength and standard deviation values

	N	Mean MPa	Std. Dev.	p-value
Sand Blasted	20	1.3975	.36165	< 0.0001
Laser Treated	20	3.5075	.63056	