International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 4 Issue 9, September-2015

# Effect of Er.Cr.YSGG laser on shear bond strength of Zirconia dioxide: An experimental and SEM study

## (Running title: Laser enhancing bonding Zirconia)

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**ABSTRACT**

**Background and objectives:** Enhancing bonding of Zirconia to luting cement is a growing topic in the last decade; increase surface roughness of zirconia has correlation with bond strength, Laser has high power effect and can create changes on the many materials surface, the purpose of this in vitro study was to evaluate the effect of laser treatment and type of luting cement on shear bond strength of CAD/CAM zirconia cylinders and evaluate the effect of laser on zirconia surface by scanning electron microscope.

**Material and Methods:** forty zirconia cylinders with 7×7 mm were placed into resin blocks divided into 2 groups: group A (n=20) zirconia discs were treated with Er.Cr.YSGG laser B (n= 20) zirconia discs were not treated with Er.Cr.YSGG laser. Then A& Bwere bonded to Multilink Automix adhesive cement with same diameter and 3 mm. After luting all samples were kept in incubator for 24 hours at 37 C°. Then the load was applied by universal testing machine at the interface between zirconia and luting cement perpendicular to the long axis of the sample until fracture occurred. Two types of zirconia (lased and non-lased) were sent to Scanning Electron Microscope to evaluate effect of laser on zirconia. Data were analyzed with two sample T test to compare the mean shear bond strength in between groups and (ONE WAY ANOVA) to compare among all groups, all at (P_value ≤0.05).

**Results:** Statistical analysis showed that the treatment with Er.Cr.YSGG laser has no significant effect on shear bond strength of zirconia and adhesive cement ($p < 0.05$), Scanning Electron Microscope images showed that laser could not produce any cracks or gaps or fissures which may increase micro-spaces on the surface of zirconia which improve micro adhesion.

**Conclusions:** Within the limitation of this in vitro study, it may be concluded that the shear bond strength of zirconia cylinder is not affected by laser treatment. SEM shows (worse effect of laser) on surface roughness of zirconia.

**Key words:** Zirconia, shear bond strength, Er.Cr.YSGG, laser, SEM

## INTRODUCTION

The frequency of esthetic restoration in dentistry has been increasing due to increased interest in beauty and esthetics. Due to this trend, there has been increasing clinical application of the all-ceramic crown, which is more esthetic and biocompatible, whilst there has been decreasing clinical application of the metal ceramic crown[1]. Zirconia is one of the most studied ceramic materials in the world since it one of the useful environmentally and friendly products. In clinical dentistry, it is widely used for the fabrication of crown copings, bridge frameworks and custom implant abutments. Its durability, biocompatibility, natural esthetics and low cost when compared to alternative restorative materials make it the ideal solution for a variety of clinical applications. Growing material advancements have produced the strongest and most reliable all-ceramic restoration, making zirconia an ideal alternative solution wherever traditional metal or Porcelain Fused to Metal restorations might be prescribed[2].

Selection of a luting agent probably is a last important decision in a series of steps that require meticulous execution and will determine the long-term success of fixed restorations[3].Although cementation of zirconia restorations with traditional luting cements (as ionomer cements) may provide adequate clinical fixation, adhesive cementation is preferable to ensure better retention and marginal adaptation[4]. Recently, all-purpose, or multipurpose self-adhesive

resin cements have been available, each purportedly bonding to enamel, dentin, amalgam, metal, and porcelain, Self-adhesive resin cements that rely on a single step application, have alsobeen proposed for luting zirconia- based restorations, For the bonding of conventional silica-based ceramics, it has been well established that adhesive bonding (hydrofluoric etching and silanization) enhances the resin bond[5].
Dental lasers provide an alternative to some conventional procedures, offering the possibility of working both on hard and soft tissues. Clinically, dental lasers utilize a focal point, which refers to the point where the beam is reduced to a minimum final target where the greatest amount of energy is emitted, one of the clinical problems encountered when using zirconia restorations that are cemented to natural teeth is that the cement cannot bond to the surface of the zirconia. Multiple surface treatments of high strength ceramics have been done with the objective of achieving a rougher surface that enhances a better mechanical bond. Etching zirconia with Laser could be an effective method to increase shear bond strength[6].

## MATERIALS AND METHODS

Forty zirconium cylinders (7mm diameter* 7 mm height) centralized inside acrylic resin in polyethylene tubes that were previously cut to 20 mm length and 18 mm diameter, figure (1)

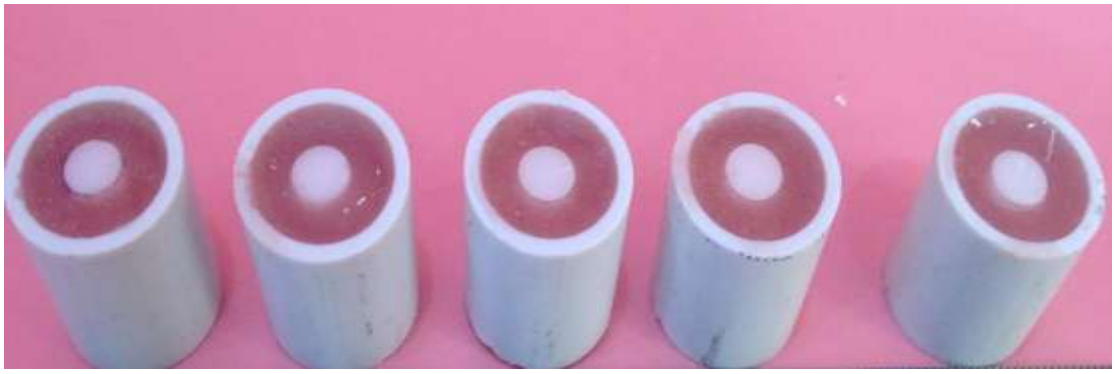

**Figure (1) Zirconia cylinder mountain in cold cure acrylic resin.**

### SAMPLE DISTRIBUTION

The 40 samples were randomly distributed into two groups 20 samples each:

Group A: zirconia discs were treated with Er.Cr.YSGG laser.
Group B: zirconia discs were left intact without any treatment

### IRRADIATION OF ZIRCONIA

Irradiation of zirconia samples were done by fixation of sample over the stage of surveyor and the handpiece of the laser device was fixed on the surveyor by a special grip constructed for this purpose figure (2),

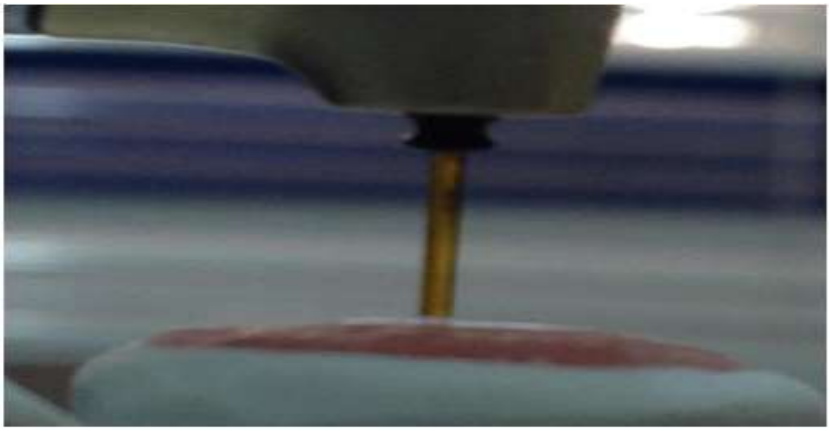

**Figure (2): the handpiece of the laser device is adapted on the surveyor by a special grip constructed for this purpose**.

the distance between the tip of the laser handpiece and the surface of the zirconia cylinder was 1 mm. figure no.(3)

**Figure (3): distance between the tip of the laser handpiece and the surface of the zirconium cylinder was 1 mm.**

Parameters of laser machine that used for this study are listed in table (1).

**Table (1): Parameters of laser machine that used for this study**

| Parameter | Value |
|---|---|
| Power | 6 watt |
| Hertz | 20 |
| Water | 30% |
| Air | 50% |
| Laser Tip size | MZ 5 |

The irradiation was continued for 90 seconds in vertical movement and 90 seconds in horizontal direction within the diameter of zirconia disc to ensure complete coverage of the entire surface by laser, with total exposure time of 3 minutes for each sample.

**APPLICATION OF ADHESIVE MATERIAL**

Each of the groups (A&B) was cemented with Multilink Automix adhesive, 40 Plastic tubes 5mm diameter, 3mm height were cut, Plastic tubes were adapted over the zirconia cylinders and fixed by glue, adhesive cements were poured into the plastic tubes over the zirconia cylinders for the both groups. According to manufacturer instructions, Multilink Automix; after washing of zirconia with water and drying with oil free air stream Monobond Plus were applied on the surface of zirconia discs for 60 seconds, then dried with oil free air, then Multilink Automix were applied on zirconia discs, then the samples were left for 24 hours, then plastic tube was removed, figure (4).

**Figure (4): samples after bonding of adhesive cements into zirconia cylinders, the plastic tube was removed**

**SHEAR BOND STRENGTH MEASUREMENT**

Measurement of shear bond strength of the samples was done by the universal testing machine. The samples were fixed via special holder fabricated for this purpose by an industrial milling machine to fit the sample size permitting suitable holding of the sample over the testing stage of the universal testing machine (Figure 5).

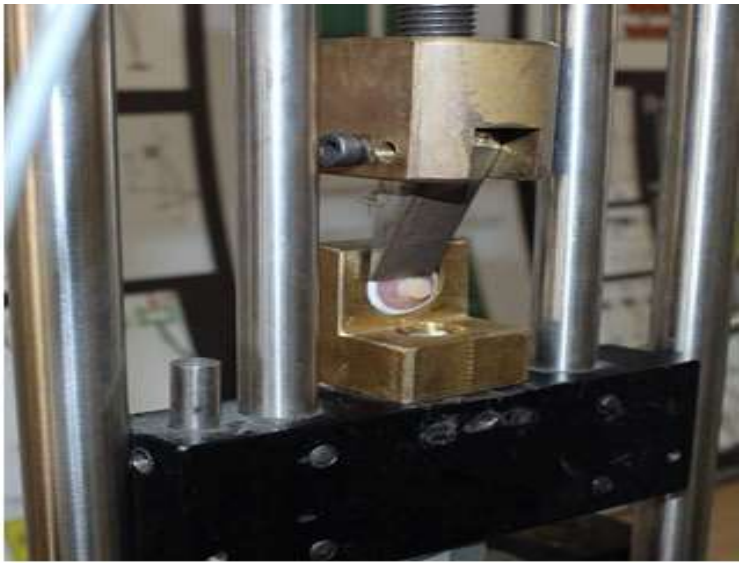

**Figure (5): Special holder was fabricated**

Then the load was applied via stain less steel knife edge head on the interface between zirconia and resin cement directed gradually downward to separate the resin cement from the zirconia, The load started from zero and increased manually and gradually until fracture occurred, and then the fracture strength recorded in Newton and mode of fracture has been observed.

**EVALUATION THE EFFECT OF LASER TREATMENT WITH SCANNING ELECTRON MICROSCOPE (SEM)**

Two samples prepared for evaluation under (SEM) in nano-technology center, university of technology, Baghdad. One sample was treated with laser as previously described and the other was left intact without any treatment. The goal of this investigation was to evaluate the effect of laser treatment on the surface of the zirconia disc

**RESULTS**

The following results were obtained from the data.

**THE EFFECT OF LASER ON SHEAR BOND STRENGTH OF ZIRCONIA**

The mean fracture strength of zirconia discs group treated with Er.Cr.YSGG laser was (80.5) N, while for the zirconia discs group left intact without any treatment was (86.5) N, The mean of intact zirconia shows obvious superiority over the mean of lased zirconia, however statistical analysis showed that the treatment of zirconia with laser has no significant effect on shear bond strength overzirconia discs group that left intact without any treatment ($p > 0.05$) as shown in (Table 2).

**Table (2): Descriptive values and statistical analysis of shear bond strength of lased and non lased groups (in Newton).**

| Zirconia disc | No | Mean | St.Dev | SE | t | Df | p-value |
|---|---|---|---|---|---|---|---|
| lased zirconia | 20 | 80.5 | 56.0 | 13 | 0.40 | 38 | 0.69 |
| intact zirconia | 20 | 86.5 | 36.7 | 8.2 | | | |

**EFFECT OF LASER TREATMENT ON ZIRCONIA SURFACE INVESTIGATED BY SCANNING ELECTRON MICROSCOPE (SEM)**

Scanning Electron Microscope examination revealed that the treatment of zirconia with Er.Cr,YSGG laser with the parameters previously mentioned having a worse effect on the surface topography and the zirconia particles. With the magnification power of 10000x and 20000x the (SEM) shows that treatment with laser leading to melting of zirconia particles and decreasing of the micro roughness of the surface of zirconia that may lead to decreasing microscopic interlock between adhesive material and zirconia as shown, figure (6) and (7).

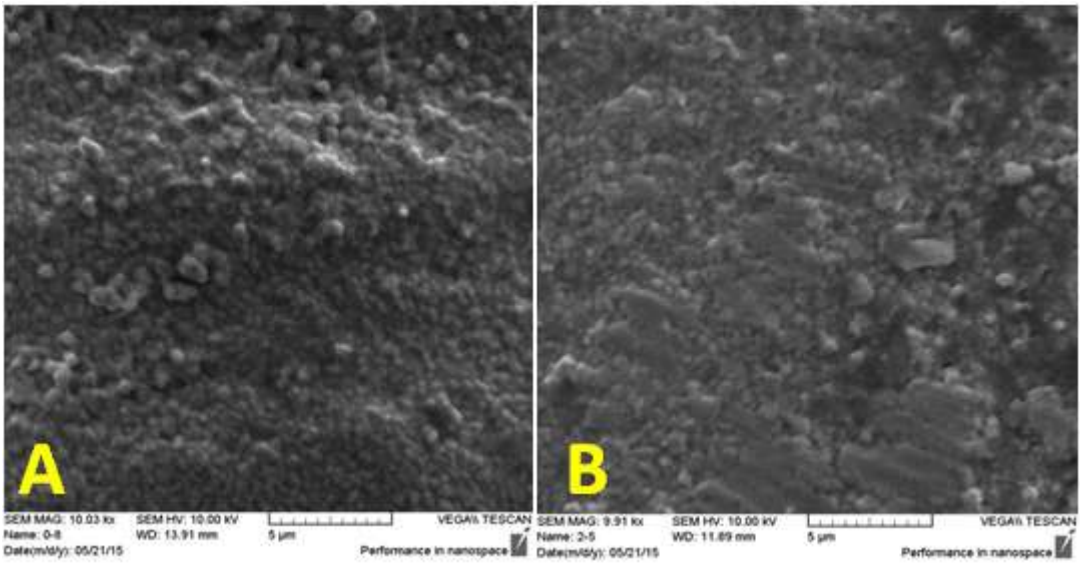


**Figure (6): SEM image magnification 10000x A: ziconia without treatment**
**B: zirconia with 6 watts laser treatment**

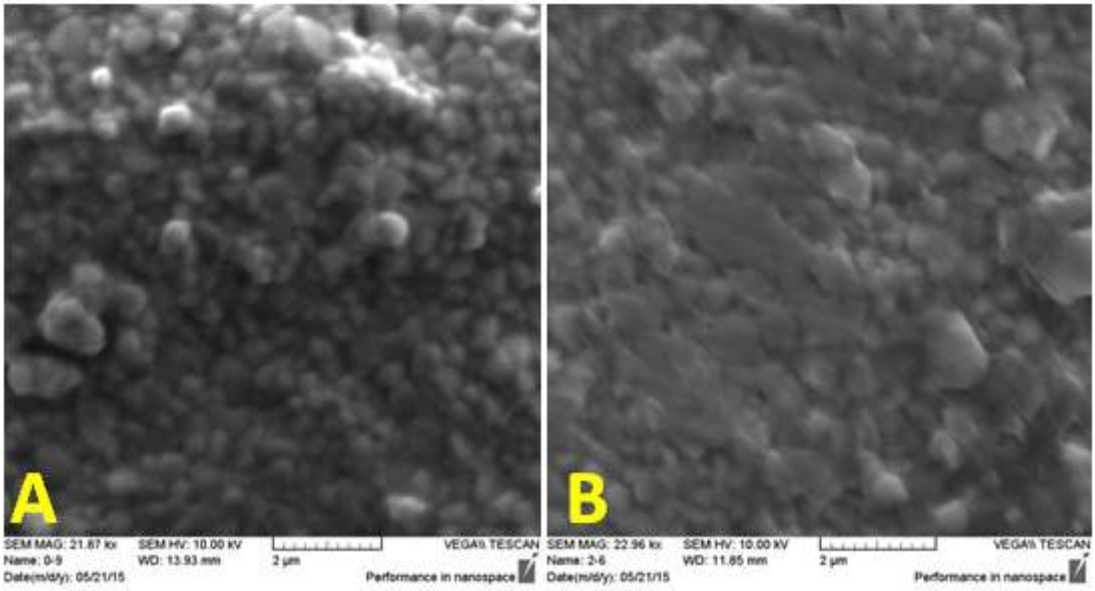


**Figure (7): SEM image magnification 20000x A : zirconia without treatment**
**B: zirconia with 6 watts laser treatment**

## DISCUSSIONS

One problem is with adhesion of conventional cementation techniques used with zirconia components do not providing sufficient bond for many applications[7]. Bonding of zirconia become a topic of great interest in the last ten years, as previously stated, traditional chemistry is ineffective on zirconia surfaces, and acids like hydrofluoric acid is not sufficiently roughen the surface for simple micromechanical attachment[8]. Phosphoric acid ($H_3PO_4$) and hydrofluoric acid (HF) etching are commonly recommended methods used to roughen the surface of silica-based ceramics[9]. This creates a rough, clean surface, which improves wettabililty and increases surface area available for mechanical

interlocking. Unfortunately, $H_3PO_4$ and HF cannot be used effectively on non silica-based ceramics, like $ZrO_2$, making it difficult to roughen the surface for mechanical retention[10,8]. The results of this study shows that there is no significant difference in shear bond strength between lased and non lased groups, however the lased zircon group shows slightly lesser shear bond strength than the non lased group. This result coincide with SEM results that shows failing of laser to increase the micro roughness of surface of zirconia, on the contrary, laser treatment decrease the surface micro roughness by melting the projection and prominence that was present before laser treatment. These results coincide with Mariano (2010)[6] who concluded that the use of Er, Cr: YSG Gand Diode Lasers caused no significant difference in flexural strength, roughness values compared to the control group, Despite, there are some differences of the values of power setting, time, but those results have agreement with this study. The results of this study achieve an agreement with Pinar Kursogluet.al (2013)[11], they concluded that Irradiation at 6 W for 1 minute may not be an efficient ceramic surface treatment technique and has no significant difference on shear bond strength.

## SCANNING ELECTRON MICROSCOPE FINDING

Er. Cr. YSGG Laser treatment with 6 Watts and 3 minutes produce reduction in shear bond strength, the assumption was that Er. Cr. YSGG laser produce melting to the particles on the surface of zirconia discs, this smoothing reduced the surface roughness and eliminated the micros paces between particles which is necessary for cementation process. Images of (SEM) show changes of zirconia surface after laser treatment; there was failing to create SIE like on zirconia surface[12], they show clearly how the laser treatment cannot produce any extra roughness on surface of zirconia. On the contrary, laser treatment produces melting, smoothing, soft undesirable zirconia surface which decrease the projections and sharp configurations of zirconia particles leading to weaker bonding strength than the untreated zirconia. And this support the assumption that mentioned above.

## CONCLUSIONS

Within the limitation of this study, it can be concluded that:

1- There is no significant effect of laser on the shear bond strength between adhesive material and zirconia..
2- Application of 6 Watts for 3 minutes of Er. Cr. YSGG laser on zirconia leading to melting and smoothing of zirconia particles which had worse effect on shear bond strength between adhesive and zirconia

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