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# Comparative Evaluation of Shear Bond Strength of Veneering Porcelain to Zirconia Core using Different Surface Treatments: An in Vitro Study

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**Abstract:** ***Surface treatments are needed to improve bond strength between zirconia and veneering porcelain. The purpose of this study was to test the shear bond strength of veneering ceramic to zirconia core after different surface treatments. The aims and objectives of the study was to evaluate the effect of surface treatments on shear bond strength between zirconia and veneering ceramic and to compare the effect of surface treatments on shear bond strength. A total of 30 square shaped zirconia samples were prepared and then divided into three groups on the basis of surface treatment. The three different surface treatments were: airborne abrasion (Group A), application of liner (Group B) and application of slurry of dentine (Group C). A cylinder of veneering ceramic was then fabricated and fired on the zirconia specimens. Each specimen was then tested for shear bond strength with the help of universal testing machine. The mean and SD shear bond strengths of the groups ranged from for (Group A) 16.01±2.57 MPa, (Group B) 15.14±1.76 MPa to (group C) 21.33± 4.16 MPa. Group C had the maximum shear bond strength followed by Group A with Group B showing minimum bond strength.***

**Keywords:** Surface treatment, zirconia, shear bond strength, veneering porcelain

## 1. Introduction

The objective of any restoration is to restore form, function and esthetics**.** Aesthetic dentistry is an art as well as science. An esthetic restoration involving anterior teeth poses a challenge to any clinician. Increasing patient expectations and the search for metal-free restorations have led to the advent of all-ceramic restorations. All-ceramic restorations must combine the mechanical properties of metal and optical properties of ceramics to be accepted as an alternative to metal ceramic restorations. At present, zirconia-based materials are the strongest, most esthetic and biocompatible materials available for all-ceramic restorations.

Zirconia has interesting micro structural properties which have contributed immensely to its increasing popularity in dentistry. The word ‘zirconium’, comes from an Arabic word Zargon(golden in color) which in turn comes from the two Persian words Zar(Gold) and Gun(color).[1] It occurs in three forms i.e. monoclinic(M), cubic(C) and tetragonal(T). Pure zirconia is monoclinic at room temperature. This phase is stable up to a temperature of 1170°C. Above this temperature it transforms into tetragonal and then on further heating, it transforms into cubic phase at temperature of 2370°C. During cooling, a tetragonal-monoclinic transformation takes place which is associated with a volume expansion of approximately 3-4%. Ruff and co-workers[1] showed the feasibility of the stabilization of C-phase to room temperature by adding small amounts of stabilizing oxides such as CaO, MgO, CeO, $Y_2O_3$ to pure zirconia leading to formation of Partially Stabilized Zirconia (PSZ). These ceramics have a unique characteristic of **“**Stress Induced Transformation” that gives them superior mechanical properties compared with other ceramics.

In 1975, Garvie[1] proposed a model to rationalize the good mechanical properties of zirconia, by virtue of which it has been called ‘‘ceramic steel’’. It has a high flexural strength (>1GPa) and fracture toughness ($K_{IC}$=9-10 $MPam^{-1}$). Zirconia ceramic is also used as endodontic posts and as implant abutments. Due to excellent physical properties and superior biocompatibility, it is being evaluated as an alternative to metal framework for full coverage crowns and for fixed partial dentures (FPD).[2]

Zirconium dioxide or Zirconia ($ZrO_2$) ceramic as a core ceramic material possesses high strength and chemical stability but lacks adequate translucency to achieve good dental aesthetics. Though zirconia framework is esthetically better accepted than metallic framework, it remains clinically too white and opaque.[3] So it has to be veneered with translucent glass ceramic to mimic the appearance of natural teeth and to enhance the esthetics. Thus, it is preferred to use zirconia as a core or infrastructure, while a glass or feldspathic ceramic must be used as an esthetic veneering material. The infrastructure of zirconia provides good masking of darkened substrates due to an adequate level of opacity, and also allows superior esthetics after veneering.

Veneering ceramic is considered to be the weakest part of all-ceramic restorations. Sufficient bond strength between the ceramic veneer and zirconia substructure is essential for the long-term clinical success of zirconia restorations. Several studies showed that cracking or chipping of veneer from core ceramics was one of the most common failure modes of zirconia all-ceramic fixed dental prostheses and can be very disappointing to the clinicians and patients.[4] Core-veneer bond strength is determined by various factors including mechanical interlocking, strength of chemical bonding, wetting properties, and transformation of zirconia crystals at the core-veneer interface due to thermal influences.[5]

To enhance the mechanical interlocking between veneer and core, various treatment procedures have been tried such as application of liners, sand-blasting or air particle abrasion, surface grinding etc. and have been found to have a significant effect on bond strength. Liners can be applied as an intermediate layer between the zirconia substrate and the veneering ceramic to mask the framework and increase the wetting properties of the zirconia surface. Airborne-particle abrasion increases surface roughness for achieving strong adhesion of veneering ceramics and zirconia.[6]

A study of literature shows that different types of surface treatments have been tested in the past but their results had been controversial.

Jen Fischer (2008)[5] et al had concluded that liner application did not affect shear strength of zirconia core to the veneering ceramic. They further did a study in the year 2010 to evaluate the effect of air particle abrasion on bond strength of different veneering ceramics to Ceria-stabilized tetragonal zirconia/alumina (Ce-TZP/A) and concluded that airborne-particle abrasion was not necessary to enhance the shear bond strength.[7] Jili Teng (2012)[8] et al in his study evaluated conditioning methods to improve core-veneer bond strength of zirconia restorations. He proved that modifying the zirconia surface with powder coating before sintering could significantly increase the shear bond strength. Atsushi Nishigori et al (2014)[9] observed that zirconia surface treatment did not significantly affect shear bond strength after cyclic loading and airborne-particle abrasion without subsequent heat treatment should be avoided as a surface treatment in fabrication methods. Aneta Mijoska et al in 2014 in her study on ceramic liners proved that liner application on the surface of zirconium oxide ceramic led to higher forces of the bonding between the two ceramic materials.[10]

Several other studies have reported that the bond strength between zirconia ceramic copings and veneering porcelain was significantly affected by different surface treatments. However, their exact influence on the bond strength of veneering porcelain and zirconia copings was still not clear.

Therefore, further studies on these surface treatments are needed to improve bond strength. The purpose of this study was to test the shear bond strength of veneering ceramic to zirconia core after different surface treatments.

### Aims and Objectives

The following were the aims and objectives of the study:

a) To evaluate the effect of surface treatments on shear bond strength between Zirconia and veneering ceramic.
b) To compare the effect of surface treatments on shear bond strength between Zirconia and veneering ceramic

## 2. Material and Methodology

This study measured the bond strength between veneering ceramic and zirconia specimen after surface treatment of zirconia with different methods.

Total sample size: 30

**Following were the materials and armamentarium of the study:**

**Materials and Armamentarium**

1) Square shaped zirconia specimen(3M ESPE Lava ™ Plus)
2) Acetone liquid
3) Diamond disc (Toboom Dental Rotary, Shanghai, China)
4) Silicone mold
5) Veneering ceramic (IPS e.max Ceram–Ivoclar Vivadent)
6) Air borne abrasion device (AX-B Twin–Pen Sandblaster, Shandong, China)
7) 110 micrometre alumina ($Al_20_3$) particles (Korex sand, Bego, Germany)
8) Liner (IPS e.max Ceram Zirliner – Ivoclar Vivadent)
9) Porcelain brush
10) Glass slab
11) Absorbent paper
12) Porcelain furnace (Samkoon Abrostatic Overseas)
13) Mounting metal jig with knife edge
14) Universal testing machine (ASI, Sales (P) Ltd .New Delhi ,Model 50 KN)

### Methodology

A total of 30 square shaped zirconia samples were prepared and then divided into three groups on the basis of surface treatment. The three different surface treatments were: Airborne abrasion, Application of liner and Application of slurry of dentine. A cylinder of veneering ceramic was then fabricated and fired on the zirconia specimens. Each specimen was then tested for shear bond strength with the help of universal testing machine.

The whole procedure was divided into four steps.

### Step I: Preparation of zirconia specimen

Thirty square shaped zirconia specimens of size 5x10x10 mm were prepared. Zirconia blocks (Fig. 1) supplied by the manufacturer in disk-shape, are partially pre-sintered blocks. It is easy to mill or shape these blocks, but they must be sintered after milling to achieve the final strength. Therefore, the size of the milled block was increased proportionately to compensate for the prospective shrinkage (20 percent) that occurs during the final sintering. Subsequently, after milling, the specimens were sintered in a high-temperature furnace (Samkoon Abrostatic Overseas) at 1500˚C for 8 hours to get the final dimension of the zirconia specimen. (Fig. 2). The specimens were ground by diamond disc (Toboom dental rotary) to the determined size of 5x10x10 mm. The specimens were cleaned in acetone for 15 minutes (Fig.3).

### Step II: Grouping of the study sample

Thirty square shaped zirconia samples were then divided into three groups and were surface treated with different methods.

Group A –Air borne abrasion with $Al_2O_3$
Group B – Company Based Liner
Group C- Slurry of Dentin Ceramic

II a Preparation of specimens of group A

Zirconia specimen was air borne particle abraded with 110 micrometre alumina ($Al_20_3$) particles under 4 bar pressure for 10 seconds at a direction perpendicular to the surface and a distance of 10mm. The nozzle of the sandblaster was moved over the surface of the specimen to abrade it as evenly as possible (Fig.4, 5). Ten samples were prepared in a similar manner.

II b. Preparation of specimens of group B
Ceramic liner (Fig.6,7) was applied using ceramic brush on the surface of zirconia specimen to create an even layer. It was then fired at a temperature of 950°C for one minute. Ten such samples were made in a similar manner.

II c. Preparation of specimens of group C
Slurry of dentine ceramic shade $D_3$ (Fig.8) was applied with a ceramic brush. It was then fired in the furnace at 950° C for one minute. Ten such samples were made in a similar manner.

**Step III. Preparation of veneering porcelain cylinder**
On the prepared surface of each specimen, a veneering porcelain cylinder was applied using a custom-made split silicone mold (Fig. 9). Porcelain powder was mixed with the appropriate amount of distilled water with brush and it was added to build a cylinder of 3 mm in diameter and 4mm in height. Excess liquid was removed with tissue paper. The specimens of zirconia with veneered porcelain was then placed in the porcelain furnace. Pre drying of the sample was done at a temperature of 450° C for five minutes. Then, firing was performed (fig. 10,11) with an increasing rate of 45°C/min from 930°C according to the manufacturer's recommendations. A second firing was required to compensate for the porcelain shrinkage that occurred during the first firing. Thus, thirty such samples of zirconia with veneered porcelain were made.

**Step IV. Testing for Shear bond Strength**
A metal jig (Fig. 12) was made with screws to hold the square-shaped sample in the universal testing machine. Each specimen was tested in a universal testing device at a crosshead speed of 1mm /min (Fig. 13). The jig was made to hold the zirconia specimen. The shear bond strength was calculated from the force required to break the porcelain cylinder from the zirconia specimen. The testing machine gave the load in kilograms. The value was multiplied by 9.8 to get the load in Newton. The Area of cylinder was calculated by $Area = \pi radius^2$. The Shear bond strength was calculated using the following formula:
Shear Bond strength (MPa) = Load (N)/area ($mm^2$).

Mean and Standard deviation (SD) values of the Shear bond strength (n=10) were analyzed statistically using a 1-way analysis of variance test (ANOVA). Tukey's multiple comparisons test was used to assess the difference among groups (α=.05). All statistical analyses were performed using the statistical software (IBM SPSS Statica 20).

## 3. Images


**Figure 1:** Zirconia block

**Figure 2:** 5x10x10 zirconia specimen

**Figure 3:** Acetone liquid

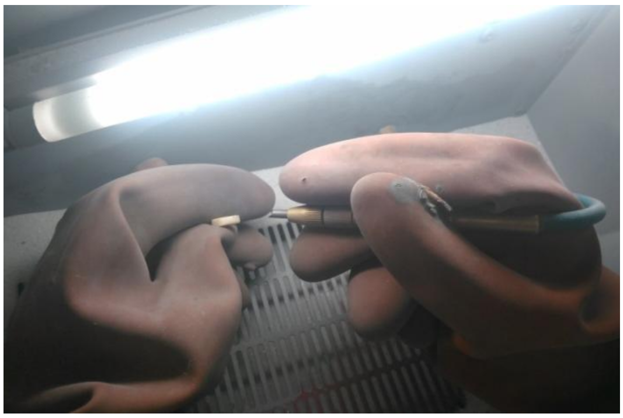


**Figure 4:** Air borne Abrasion

**Figure 5:** Sand Blaster

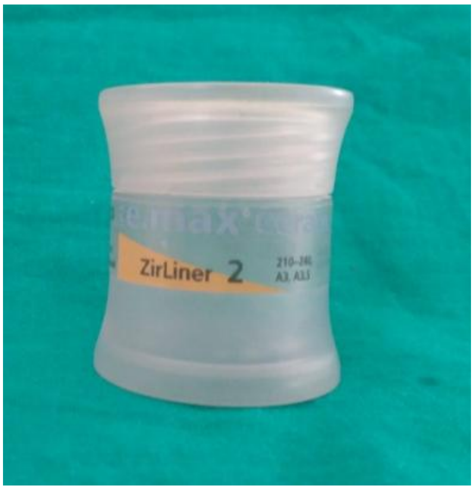



**Figure 6:** Ceramic liner

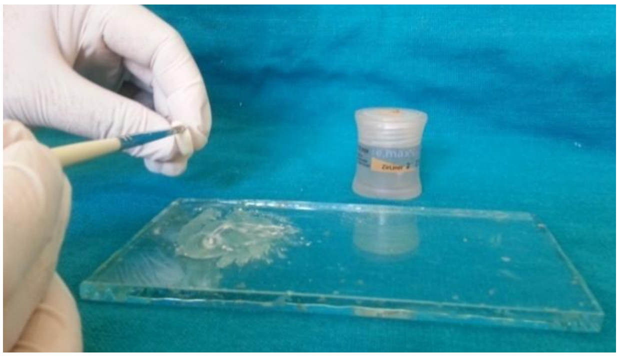


**Figure 7:** Ceramic Liner applied with brush


**Figure 8:** Slurry of dentine ceramic shade $D_3$

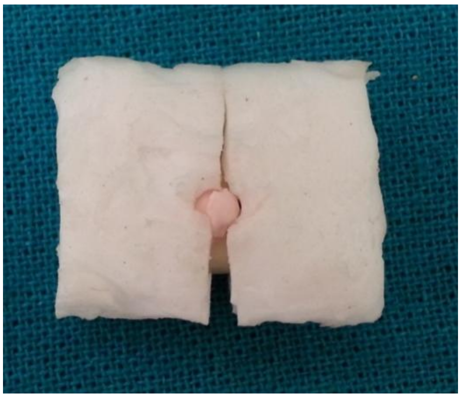


**Figure 9:** Custom-made split silicone mold

**Figure 10:** Porcelain furnace

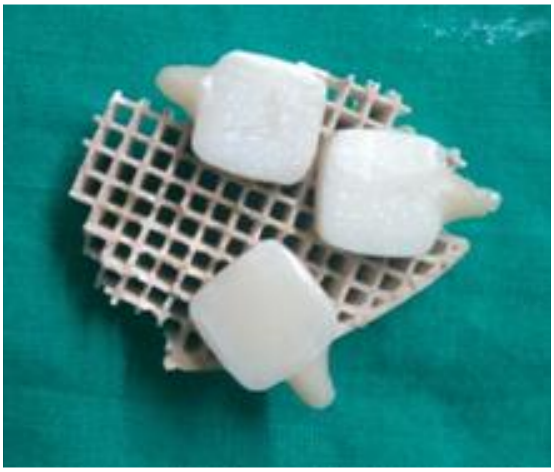


**Figure 11:** Prepared zirconia specimen with veneered porcelain cylinder

**Figure 12:** Metal jig

## 4. Results

All the three groups i.e. Group A (air borne abrasion with $Al_2O_3$), Group B (Company Based Liner) and Group C (Slurry of Dentin Ceramic) which were surface treated with different methods were evaluated for shear bond strength in MPa. Each group was checked for null hypothesis.

***Null hypothesis: The null hypothesis was that the shear bond strength of veneering ceramic with non treated zirconia would not be different from that of veneering ceramic.***

The mean and SD shear bond strengths of the groups ranged from (Group A) 16.01±2.57 MPa, (Group B) 15.14±1.76MPa to (Group C) 21.33± 4.16MPa. Group C had the maximum shear bond strength followed by Group A and least with Group B.

The comparison of shear bond strength of all the three groups is mentioned in Table I.

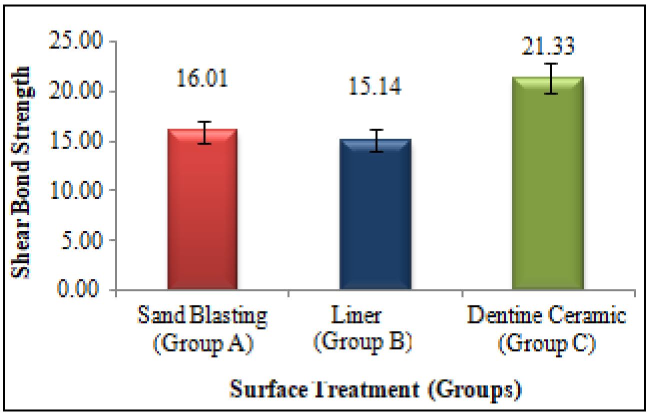
**Table 1:** Shear Bond strength of all the three groups in (MPa) of each specimen

| Samples | Sand Blasting (Group A) | Liner (Group B) | Dentine Ceramic (Group C) |
|---|---|---|---|
| 1 | 19.7 | 14.9 | 24.4 |
| 2 | 18.9 | 17.2 | 23.2 |
| 3 | 17.04 | 14.2 | 30.4 |
| 4 | 18.4 | 14.2 | 23.6 |
| 5 | 12.7 | 11.4 | 16.7 |
| 6 | 15.1 | 17.4 | 19.3 |
| 7 | 15.7 | 14.9 | 17.1 |
| 8 | 12.7 | 14.9 | 19.2 |
| 9 | 13.3 | 16.6 | 18.7 |
| 10 | 16.6 | 15.7 | 20.7 |

**The Mean of the three groups were as follows:**

1) **Group A:** Shear Bond Strength of (group A) ) =16.01 MPa
2) **Group B:** Shear Bond Strength of (group B) =15.14 MPa
3) **Group C:** Shear Bond Strength of (group C) = 21.33 MPa

Graph I shows the bar chart to compare the bond strength of the three groups with their standard deviation




**Graph I. Mean shear bond strength of surface treated groups**

Therefore, the obtained data is showing a significant difference among groups with different surface treatments, so it rejected the null hypothesis (Table III). The one -way analysis of variance is showing a significant difference in the shear bond strengths between groups (F =12.489, df=2, P<0.01) in table IV. Tukey Multiple Comparison results are mentioned in

**Table IV:** The "IBM SPSS Statistics 20" was used for the analysis of results

| Descriptive | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
| | | | | | Lower Bound | Upper Bound | | |
| Sand Blasting (Group A) | 10 | 16.01 | 2.57 | 0.81 | 14.18 | 17.85 | 12.70 | 19.70 |
| Liner (Group B) | 10 | 15.14 | 1.76 | 0.56 | 13.88 | 16.40 | 11.40 | 17.40 |
| Dentine Ceramic (Group C) | 10 | 21.33 | 4.16 | 1.32 | 18.36 | 24.30 | 16.70 | 30.40 |
| Total | 30 | 17.49 | 4.01 | 0.73 | 16.00 | 18.99 | 11.40 | 30.40 |

**Table II. Mean, standard deviation and range of surface treated groups.**

The descriptive statistics for the three groups have been presented in the table II.

Results showing that the mean SBS of the group B (liner) has been lowest at 15.14MPa approximately with standard deviation of 1.76. On the other hand, the results showing that average bond strength of the group C (slurry of dentine) is highest at 21.33MPa with standard deviation of 4.16 followed by group A (air borne abrasion ) for which the average bond strength has been 16.01MPa with standard deviation of 2.57. The minimum value has been lowest for the liner group B is at 11.40MPa. Also, the minimum value has been highest for the dentine ceramic group C is at 16.70MPa. The maximum value has been lowest for the liner group (B) at 17.40MPa while maximum value has been highest for the group (C) dentine ceramic at 30.40MPa

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Source of Variance | Sum of Squares | df | Mean Square | F | p value | Sig. |
| Between Groups | 224.466 | 2 | 112.233 | 12.489 | .001 | HS |
| Within Groups | 242.635 | 27 | 8.986 | | | |
| Total | 467.101 | 29 | | | | |

**Table III. Showing one way ANOVA**

One way ANOVA has been conducted to test that there has been significant difference between the mean for shear bond strength. The results presented for the one way ANOVA are showing that the p-value for the F-Stat is close to zero, which means that there has been statistically significant difference between the mean of at least one of these pairs. The value of F (12.489) for df (2, 27) and p=0.001 is significant.

**Table IV:** Tukey Multiple Comparison

| Tukey Multiple Comparisons | | | | | | |
|---|---|---|---|---|---|---|
| (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | p value | 95% Confidence Interval | |
| | | | | | Lower Bound | Upper Bound |
| Sand Blasting (Group A) | Dentine Ceramic (C) | -5.316* | 1.341 | .001 | -8.640 | -1.992 |
| | Liner (B) | 0.874 | 1.341 | .793 | -2.450 | 4.198 |
| Liner (Group B) | Dentine Ceramic (C) | -6.190* | 1.341 | .001 | -9.514 | -2.866 |
| | Sand Blasting (A) | -0.874 | 1.341 | .793 | -4.198 | 2.450 |
| Dentine Ceramic (Group C) | Liner (B) | 6.190* | 1.341 | .001 | 2.866 | 9.514 |
| | Sand Blasting (A) | 5.316* | 1.341 | .001 | 1.992 | 8.640 |

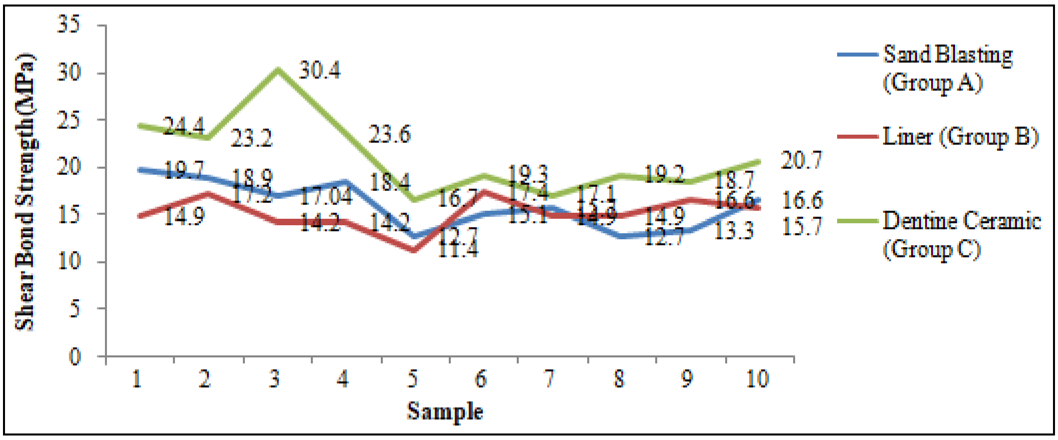
**The mean difference is significant at the 0.05 level.**

The analysis of Tukey Multiple Comparison test is as follows:

**Air borne abrasion and dentine ceramic:** The value of the difference between the mean of air borne abrasion and dentine ceramic i.e. -5.316 which indicates that both groups had statistically significant difference. The p-value has been equal to 0.001 which showed that group C is better than group A.

**Air borne abrasion and liner:** The value of the significant difference between the mean of group A and group B has been equal to 0.874 which indicates that the mean of the air borne abrasion has been higher than that of the mean of liner by 0.874. The p-value of the test is 0.793 But on the basis of mean value group A (16.01) is better than the group B (15.14).

**Liner and dentine ceramic:** The value of the significant difference between the mean is 6.190 which indicates the mean of the liner (15.14) has been lower than the mean of ceramic (21.33). The p- value has been 0.001 which is significant. This shows that Group C is better than group B.




**Graph I:** Shear Bond Strength of samples

In group (A) sand blasting mean score is 16.01, in group (B) liner is 15.14 and group (C) is 21.33. Group (B) has lower mean score as compared to groups A and C.

## 5. Discussion

Zirconia-based materials are used as the core for crowns and for fixed dental prostheses (FDPs) in restorative dentistry because of their superior esthetics, biocompatibility, and improved mechanical properties. However, clinical failures such as chipping or delamination[4] of veneering ceramic have been reported in several patients. The optimal shear bond strength of veneering ceramics with zirconia should resist delamination. Bond strength is determined by a range of factors including strength of chemical bonds, mechanical interlocking, type and concentration of defects at the interface, wetting properties, and the degree of compressive stress in the veneering layer.[5] Various surface treatments have been tried in the past to improve the core-veneer bond strength but their influence has been a subject of controversy. Hence, a study was conducted to evaluate the effect of different surface treatments on the shear bond strength between zirconia and veneering ceramic.

In the present study, thirty square shaped zirconia samples were divided into three groups (A, Band C) which were subjected to different surface treatments; group A was treated with air borne abrasion with 110µm $Al_2O_3$ under 4 bar pressure for 10 seconds, group B was surface treated with company based liner and group C was painted with slurry of dentin ceramic.

Air borne abrasion increases surface energy and produces an active surface for formation of bond. These rough surfaces contribute to improved micromechanical interlocks of the bonding interface. However, it is considered that sandblasting may put stress on zirconia surfaces and accelerate tetragonal-to-monoclinic (t→ m) phase transformation.[6] It may cause micro fractures that would reduce functional strength and lead to catastrophic failure.

Liners are materials that should ensure physical bond and compensate inadequate coefficient of thermal expansion. Composition of liners varies depending on the manufacturer, but the primary component is $SiO_2$.They are products similar to opaque ceramic, and they can provide surface roughness, modify shade and improve bonding to the porcelain. Zirconia ceramics have the considerable drawback of being essentially white and opaque. The liner material is used to mask the white color of zirconia and improve the wetting property of the zirconia core.[4,13]

The third group was the application of slurry of ceramic dentine. This group can be considered as control as the surface of zirconia specimen was not subjected to any specific treatment but only a thin mix of dentin ceramic, with similar composition to that of veneering porcelain, was painted on the zirconia surface.

Subsequently, porcelain layering was done which means the cylinder of veneering ceramic was built up to final contour as guided by the custom made mould and then fired onto the framework.

It was found that group C (slurry of dentine ceramic) had the maximum shear bond strength (21.33 MPa), followed by group A (air abrasion) (16.02 MPa) and later by group B (liner) (15.14 MPa) which had the least shear bond strength. Hence, in our study, sandblasting (Group A) and liner application (Group B) did not enhance the bond strength.

These results are in concordance with the study by Fischer et al (2008)[5] who tested the influence of polishing, sandblasting, silica coating and liner application on the zirconia surface on bonding with five veneering ceramics. They found that neither sandblasting nor polishing improved the shear strength. According to them, chemical bonds are established between both materials during firing. Consequently, surface roughness as created by sandblasting was not necessary to enhance bond strength. In their study, liner application did not affect shear strength. Fischer et al also stated that the bond strength between zirconia and the veneering ceramic was higher than the cohesive strength of the veneering ceramic. In other words, the weakest link was not the interface but the veneering ceramic itself.

In another study by Fischer et al (2010), cubes of Ceria stabilized -zirconia/alumina (Ce-TZP/A, edge length, 10 mm) (NANOZR) were layered with veneering ceramics (Cerabien ZR, 5 mm in thickness) with or without application of a liner and sheared at the interface. The effect of different surface treatments such as polishing with 3-µm diamond paste and airborne-particle abrasion was also evaluated. Mean shear bond strength values (MPa) were calculated. It was observed that the application of a liner on Y-TZP had no significant effect and airborne-particle abrasion was not necessary to enhance the shear bond strength. They suggested that liners rather impaired the shear bond strength of veneering ceramics to Ce-TZP/A. Again, these results support the results of our study.[7]

In a similar study, Mijoska A et al (2014)[10] studied the role of liners in bonding zirconia to veneering porcelain. Twenty four bilayered ceramic specimens were made, and then tested with shear bond strength test using a notched edge to determine the form of separation and the type of fracture. The resulting values for shear strength were calculated and expressed as the strength of the connection (MPa), compared with the control samples without liner. The strength of the interface of zirconium-ceramic veneers was significantly higher than the minimum force required in conventional metal-ceramic restorations. It was concluded that the procedure of liner application on the surface of zirconium oxide ceramic led to higher forces of the bonding between two ceramic materials and should be an integral part of everyday clinical practice.[10] Their results are contradictory to our results wherein the application of liner has decreased the bond strength of zirconia and veneering ceramic.

However, in another investigation in 2014, Mijoska A et al[11] contradicted their own results in the previous study and discouraged the use of liners. They tested five surface treatments: cleaning in an ultrasonic bath and treating with SiC-discs, air particle abrasion with alumina oxide ($Al_2O_3$), application of liner, tribochemical air abrasion with Rocatec system (3M ESPE, USA) and silane primer. It was found that tribochemical air borne abrasion showed highest values of the shear stress, air borne abrasion and grinding decreased the shear bond strength, whereas lowest value of the shear strength was observed in liner group. This study supports our results.

In another study (Hatta M et al 2011)[12] yttrium partially stabilized zirconia (YTZ) was veneered with Nobel Rondo Zirconia Dentin A2 High Value (NZR). NZR was fired to zirconia. The fabricated specimen was subjected to shear force testing. Mean shear bond strength was 23.3 MPa. This value is in concordance with our results wherein group C (surface treated with slurry of Dentin Ceramic) had the mean shear bond strength of 21.33 MPa.

Atsushi Nishighori et al (2014)[9] further investigated the influence of yttria-stabilized tetragonal zirconia polycrystal surface treatment and cyclic loading on veneering porcelain shear bond strength. The treatments were: heat treatment of 650°C to 1000°C at 55°C/min; airborne-particle abrasion, and heat treatment after abrasion. They concluded that airborne-particle abrasion without subsequent heat treatment should be avoided as a surface treatment in fabrication methods which further substantiates our study.

Kim et al. (2011)[13] in a similar study design demonstrated that application of a liner increased the possibility of interfacial failure of veneering ceramic at the zirconia core, and that airborne-particle abrasion may be more useful for increasing bond strength than liner application.

Teng Jili et al (2012)[8] evaluated polishing with up to 1200 grit silicon carbide paper under water cooling, airborne-particle abrasion with 110 μm alumina particles, and modification with zirconia powder coating before sintering and suggested that modifying the zirconia surface with powder coating could significantly increase the shear bond strength of zirconia to veneering porcelain.

Wang et al (2014)[14] and Subasi et al (2014)[15] found that liner application and airborne abrasion –particle abrasion seem to reduce zirconia /veneer interfacial toughness. Therefore, the two surface treatment methods should be applied with caution.

Shear bond strength (SBS) test is used in this study because of easy preparation of the specimens and simple test protocol. It is not considered as a true indicator of bond strength due to its non homogenous stress distribution in bonding. Other test methods for bond strength evaluation of veneering porcelain to frameworks namely, three and four point flexure, tensile, and microtensile bond tests have been recommended in the literature. They all have certain disadvantages as they are more tedious and time consuming.[16]

A major limitation of present study was that being a laboratory study, it could not simulate intraoral conditions. The design of the specimens was not similar to the intraoral size and contour of zirconia crowns. Moreover, different fracture patterns of veneer delamination depend on the occlusal forces and position of opposing teeth in clinical situations. Hence, the specimens in this study did not fully reflect the clinical situation.

The differences in failure mode whether adhesive or cohesive were not observed in the present study. In addition, the porcelain layering procedure was performed with 1 to 2 repetitions of layering and firing. In conventional laboratory procedures, repeated layering and firing processes are generally performed. The contraction and expansion that occurs with these repeated procedures may result in variable bond strength values. The effect of variation in temperature and cyclic loading on the shear bond strength is difficult to be simulated on test specimens. However; in vitro studies give a fair idea regarding the properties and behavior of dental materials.

In our study the type of failure was assumed to be adhesive in nature. Future studies by scanning electron microscope are recommended to determine the nature of interfacial failure. Observations based on the present results rejected the hypothesis that the shear bond strength of veneering ceramic with non treated zirconia would not be different from that of veneering ceramic.

## 6. Conclusion

Within the limitations of this in vitro study, the following conclusions are drawn.

1) Airborne particle abrasion is not required to increase the shear bond strength of veneering ceramics to zirconia core.
2) The application of liner results in significant decrease in the shear bond strength.
3) The direct application of slurry of dentine with zirconia specimen gives maximum shear bond strength.
4) This difference suggests that air-particle abrasion and liner application should be avoided in clinical situations as a surface treatment

## References

[1] Piconi C, Maccauro G. Review Zirconia as a ceramic biomaterial. Biomaterials 20 (1999)1-25.
[2] Baldassarri M, Stappert CFC, Wolff MS, Van P. Thompson VP and Yu Zhang Y. Dent Mater. Residual Stresses in Porcelain-veneered Zirconia Prostheses.2012 August; 28(8): 873–879.
[3] Oh JW, Song KY, Ahn SG, Park JM, Lee MH, Seo JM. Effects of core characters and veneering technique on biaxial flexural strength in porcelain fused to metal and porcelain veneered zirconia. J Adv Prosthodont 2015; 7:349-57.
[4] Komine F, Strub J R, Matsumura H. Bonding between layering materials and zirconia frameworks. Japanese Dental Science Review 2012; 48, 153-161.
[5] Fischer J, Grohmann P, and Stawarczyk B. Effect of Zirconia Surface Treatments on the Shear Strength of Zirconia /Veneering Ceramic Composites. Dental Materials Journal 2008; 27(3): 448-454.
[6] Pardo NP, Araya L, Pardo MP. Effects of different surface treatments on the bond strength of a resin cement in zirconia frameworks. J Int Dent Med Res 2016;9:(1) pp1-5
[7] Fischer J, Stawarczyk B, ling D, Sailer I, Hammerle CHF. Shear bond strength between veneering ceramics

and ceria-stabilized zirconia/alumina. J Prosthet Dent2010; 103:267-274.
[8] Teng J, Wang H, Liao Y, and Liang X. Evaluation of a conditioning method to improve core-veneer bond strength of zirconia restorations. J Prosthet Dent 2012; 107:380-387.
[9] Nishigori A, Yoshida T, Bottino MC, and Platt JA. Influence of zirconia surface treatment on veneering porcelain shear bond strength after cyclic loading. J Prosthet Dent 2014; 112: 1392-1398.
[10] Mijoska A. Popovska M, Kapusevska B, Bajraktarova VE. The Role of Liners in Bonding Zirconia to Veneering Porcelain. International Journal of Science and Research (IJSR) ISSN Volume 4 Issue 11, November 2015:1873-1877.
[11] Mijoska A, Popovska M. Evaluation of zirconia bonding to veneering porcelain. Macedonian pharmaceutical bulletin, 60 (2) 51 - 56 (2014).
[12] Hatta M ,Shinya A, Yokoyama D, Gomi H, Vallittu PK, Shinya A .The effect of surface treatment on bond strength of layering porcelain and hybrid composite bonded to zirconium dioxide ceramics. Journal of Prosthodontic Research, 2011; 55, 146–153.
[13] Kim HJ, Lim HP, Park YJ, Vang MS. Effect of zirconia surface treatments on the shear bond strength of veneering ceramic. J Prosthet Dent 2011; 105:315-322.
[14] Wang G, Zhang S, Cuirong B, Kong H. Effect of zirconia surface treatment on zirconia/veneer interfacial toughness evaluated by fracture mechanics method. Journal of Dentistry 42 (2014) 808-815.
[15] Subasi MG, Demir N, Kara O, Ozturk N, Ozel F. Mechanical properties of zirconia after different surface treatments and repeated firings. J Adv Prosthodont 2014; 6:462-7.
[16] Kim KY, Kwon TK, Kang TJ, Yang JH, Lee SJ , Yeo IS. Digital veneering system enhances microtensile bond strength at zirconia core veneer interface. Dental Materials Journal, 2014; 33(6):792-8.
[17] Fischer J, Stawarzcyk B, Trottmann A, Hammerle CHF. Impact of thermal misfit on shear strength of veneering ceramic/zirconia composites. Dental Materials 25 (2009)419-423.
[18] Tinschert J, Natt G, Mautsch W, Augthun M, Spiekermann H. Fracture resistance of lithium disilicate-, alumina, and zirconia-based three-unit fixed partial dentures: a laboratory study. Int J Prosthodont. 2001 May-Jun; 14(3):231-8.
[19] Bona AD, Anusavice KJ. Microstructure, Composition, and Etching Topography of Dental Ceramics. Int J Prosthodont 2002; 15:159–167.
[20] Isgro G, Pallav P, Zel JMV, and Feilzer AJ. The influence of the veneering porcelain and different surface treatments on the biaxial flexural strength of a heat-pressed ceramic. J Prosthet Dent 2003; 90:465-73.
[21] Al-Dohan HM, Yaman P, Dennison JB, Razzoog ME, and Lang BR. Shear strength of core-veneer interface in bi-layered ceramics. J Prosthet Dent 2004; 91:349-55.
[22] Kelly JR. Dental Ceramics: Current thinking and trends. Dent Clin N Am 48 (2004)513-530.
[23] Aboushelib MN, de Jager N, Kleverlaan C J, Feilzer AJ. Microtensile bond strength of different components of core veneered all-ceramic restorations. Dental Materials (2005)21,984-991.
[24] Steyern PVV, Carlson P and Nilner K. All-ceramic fixed partial dentures designed according to the DC-Zirkon technique. A 2-year clinical study Journal of Oral Rehabilitation 2005 32; 180–187.
[25] White SN, Miklus VG, McLaren EA, Lang LA and Caputo AA. Flexure strength of a layered zirconia and porcelain dental all-ceramic system. J Prosthet Dent 2005; 94:125-31.
[26] Papanagiotou HP, Morgano SM, Giordano RA, and Pober R. In vitro evaluation of low-temperature aging effects and finishing procedures on the flexural strength and structural stability of Y-TZP dental ceramics. J Prosthet Dent 2006; 96:154-64.
[27] Manicone PF, Iommetti PR, Raffaelli L. An overview of zirconia ceramics: Basic properties and clinical applications. Journal of dentistry 35 (2007) 819- 826.
[28] Chaiyabutr Y, McGowan S, Phillips KM., Kois JC and Giordano RA. The effect of hydrofluoric acid surface treatment and bond strength of a zirconia veneering ceramic .J Prosthet Dent.2008;100:194-202.
[29] Beuer F, Schweiger J, Eichberger M, Kappert HF, Gernet W, Edelhoff D. High strength CAD/CAM fabricated veneering material sintered to zirconia copings –A new fabrication mode for all-ceramic restorations. Dent Mater 2009; 25:121-8. Epub 2008 Jul 11.
[30] Yang B, Lange JHC, Scharnberg M, Wolfart S, Ludwig K, Adelung R, Kern M. Influence of saliva contamination on zirconia ceramic bonding. Dent Mater 2008; 24:508-13.
[31] Guess PC, Kulis A, Witowski S, Wolkewitz M, Zhang Y, Strub JR. Shear bond strengths between different zirconia cores and veneering ceramics and their susceptibility to thermocycling. Dent Mater 2008; 24:1556-67.
[32] Choi BK, Han JS, and Yang JH, Lee JB, Kim SH. Shear bond strength of veneering porcelain to zirconia and metal cores. J Adv Prosthodont 2009; 1:129-35.
[33] Aboushelib MN, Ghoniem, Mirmohammadi H and Ziad S. General principles for achieving adequate bond to all ceramic Restoration. Journal of Dentistry and Oral Hygiene Vol. 1(3), pp. 036-041, September, 2009
[34] Komine F, Blatz M and Matsumura H. Current status of zirconia-based fixed restorations. J Oral Sci 52, 531-539, 2010
[35] Aboushelib MN. Long Term Fatigue Behavior of Zirconia Based Dental Ceramics. Materials 2010, 3, 2975-2985.
[36] Rismanchian M, Shafi S, Askari N, Khodaeian N .Comparison of shear bond strength of two veneering ceramics to Zirconia. Dent Res J 2012; 9:628-33.
[37] Choi JE, Waddell JN, Swain MV. Pressed ceramics onto zirconia. Part 2: Indentation fracture and influence of cooling rate on residual stresses. Dental Materials 27 (2011) 1111–1118.
[38] Quinn JB, Sundarb V, Parry EE, and Quinn GD. Comparison of edge chipping resistance of PFM and veneered zirconia specimens. Dent Mater. 2010 January; 26(1): 13–20.
[39] Flinn BD, de Groot DA, Mancl LA, and Raigrodski AJ. Accelerated aging characteristics of three ytttria-

stabilized tetragonal zirconia polycrystalline dental materials. J Prosthet Dent 2012;108:223-230.
[40] Komine F, Fushiki R, Koizuka M, Taguchi k, Kamio S and Matsumura. Effect of surface treatment on bond strength between an indirect composite material and a zirconia framework. Journal of Oral Science, Vol. 54, No.1, 39-46, 2012.
[41] Choi YS, Kim SH, Lee J, Han JB, Han JS, Yeo IS .In vitro evaluation of fracture strength of zirconia restoration veneered with ceramic materials. J Adv Prosthodont 2012; 4:162-9.
[42] Mainjot AK, Schajer GS, Vanheusden AJ, Sadoun MJ. Influence of zirconia framework thickness on residual stress profile in veneering ceramic: Measurement by hole-drilling. Dental Materials 28 (2012) 378-384.
[43] Ting S, Lonquan S, Bin D, NinG W Shear bond strengths between ceramic cores and veneering ceramics of dental bi-layered ceramic systems and the sensitivity to thermocycling. Ceramics – Silikáty 56 (3) 238-244 (2012)
[44] Vidotti HA, Pereira JR, Insaurralde E, Fraga de Almeida ALP , Lins do Valle Acacio Thermo and mechanical cycling and veneering method do not influence Y-TZP core/veneer interface bond strength. Journal of dentistry 41 (2013) 307–312.
[45] Aktas G, Sahin Erdal, Vallittu P, Lassila L. Effect of coloring green stage zirconia on the adhesion of veneering ceramics with different thermal expansion coefficients. International Journal of Oral Science (2013) 5,236–241.
[46] Almeida JAA, Longhini D, Domingues N B, Santos C, Adabo G L Effects of extreme cooling methods on mechanical properties and shear bond strength of bilayered porcelain/3Y-TZP specimens. Journal of dentistry 41 (2013) 356 – 362.
[47] Akar GC, Pekkan G, Cal E, Eskitasscoglu G and Ozcan M. Effects of surface-finishing protocols on the roughness, color change, and translucency of different ceramic systems. J Prosthet Dent 2014; 112:314-321.
[48] Daou EE. The Zirconia Ceramic: Strengths and Weaknesses. Open Dent J. 2014; 8: 33–42.
[49] Kareem IH, Al-Azzawi HJ. Effect of zirconia surface treatments on the shear bond strength of veneering ceramic. J Bagh Coll Dentistry 2014; 26(3):13-17.
[50] Ramos CM, Cesar PF, Mondelli RFL, Tabata AS, Santos JD, and Borges AF S. Bond strength and Raman analysis of the zirconia-feldspathic porcelain interface. J Prosthet Dent 2014; 112:886-894.
[51] Broseghini C, Broseghini M, Gracis S, Vigolo P (2014) Aesthetic Functional Area Protection Concept for Prevention of Ceramic Chipping with Zirconia Frameworks. Int J Prosthodont 2014; 27:174–176.
[52] Barizon KTL, Bergeron C, Bergeron MA, Vargas M A, Qian F, Cobb DS, Gratton DG, and Geraldeli S. Ceramic materials for porcelain veneers: Part II. Effect of material, shade, and thickness on translucency. J Prosthet Dent 2014; 112:864-870.
[53] Hallmann L, Ulmer P, Wille S, and Kern M. Effect of differences in coefficient of thermal expansion of veneer and Y-TZP ceramics on interface phase Transformation. J Prosthet Dent 2014; 112:591-599.
[54] Ozcan M, Swift E J. Airborne Particle Abrasion of Zirconia Fixed Dental Prostheses. Journal of Esthetic and Restorative Dentistry, 2014; Vol 26 No 6:359–362.
[55] Tuncel I, Ozat P, Erdal E. Effects of coloring procedures on zirconia/veneer ceramics bond strength. J Adv Prosthodont 2014; 6:451-5.
[56] Alsulami U, Alshihri A, Huraib W, Alzahrani T, Albakkar H(2015). Effect of Coefficient of Thermal Expansion on Ceramic-Zirconia Interface. Int J Dent Med Res 2015; 1(6):1-6.
[57] Rana A T, Walid A Z, Samah S. Influence of Surface Conditioning Protocols on Reparability of CAD/CAM Zirconia-reinforced Lithium Silicate Ceramic. J Adhes Dent 2016; 18: 135–141.
[58] Rondoni D. Zirconia: some practical aspects from the technologist's point of view. The International Journal of Esthetic Dentistry. volume11. Number 2. Summer 2016:270-274.
[59] Aalaei S, Nematollahi F, Vartanian M, Beyabanaki E. Comparative Study of Shear Bond Strength of Three Veneering Ceramics to a Zirconia Core. J Dent Biomater, 2016; 3(1):186-191.