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# COMPARISON BETWEEN CHAIR-SIDE AND LABORATORY AIR PARTICLE ABRASION ON SHEAR BOND STRENGTH OF 3 DIFFERENT TYPES OF ZIRCONIA TO COMPOSITE RESIN

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### *ABSTRACT*

**Purpose:** To compare between the effect of chair-side and laboratory air particle abrasion (APA) on shear bond strength of different types of zirconia to composite resin.

**Materials and Methods**: Study was divided into 2 groups (n=36): laboratory (L) and chair-side (C) according to APA application methods. Each group was further divided into 3 subgroups according to type of zirconia used (High-Translucency (HT), Super-Translucency (ST), and Top-Translucency (TT)). Using CADCAM 8x8x3 zirconia cuboids were constructed, cleaned and sintered. Composite cuboids having dimensions of 6x6x3 were also constructed using custom made plexi-plates. Composite cuboids were cemented centrally to the zirconia cuboids with light cure under 5kg for 6 mins. After thermocycling for 1000 cycles, all specimens were dried and collected for testing. The shear bond strength of the specimens was measured utilizing universal testing machine at a crosshead speed of 0.5 mm/min. Failure load was recorded in Newton and SBS was calculated as follows: SBS (MPa) = load (N)/area(mm2).

**Results:** CHT scored the highest mean SBS (12.69±5.59) followed by CST (11.38 ±3.42) and then CTT (8.13±3.4). All chair-side mean SBS values were more than lab SBS values. LHT (7.87±5.17), LTT (7.4±5.75) and the least was LST (6.00±2.48). T-student test revealed significant difference between tested groups (P=0.001).

**Conclusions**: Chair- side APA showed higher mean values of SBS and may present a logical and practical alternative to lab APA in treating zirconia surfaces before cementation.

**Key words**: super-translucency zirconia, top-translucency zirconia, high-translucency zirconia, translucency, chair-side APA, laboratory APA.

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## INTRODUCTION

Zirconia-based ceramics gained popularity in restorative dentistry due to its new aesthetic blocks alongside with biocompatibility, excellent physical and mechanical properties when compared to other dental ceramics.

However, the chemical inert nature of this material created a challenge to establish a strong durable adhesive bond with resin-based luting agents due to resistance of its surface to acid etching or silanization (Cheung and Botelho, 2015; Cheung, Botelho and Matinlinna, 2014; El- Korashy and El-Refai, 2014). This resistance is because of its silica-free ($S_iO_2$) structure (Gomes et al., 2013; Pardo; Araya and Pardo, 2016).

Unfortunately, most clinical failures appeared to be related to bonding and cementation procedures associated with internal surface of restoration (Thomas, 2013). As a result, different efforts were made to improve the surface properties of zirconia, and various surface treatments were proposed to achieve stronger, durable and long-lasting bond (El- Korashy and El-Refai, 2014; Pardo, Araya and Pardo, 2016).

"Surface treatment of ceramics increases the surface area and creates micro porosities on the ceramic surface that will eventually enhance the potential for the mechanical retention of the luting composite resin" (Saker, Ibrahim and Ozcan, 2013; Kirmali, Akin and Kapdan, 2013). As a result, it is very important to create a surface that is micro mechanically prepared and chemically activated (Bielen et al., 2015). Air particle abrasion using alumina ($Al_2O_3$), silica coating, hydrofluoric acid treatment and laser treatment are different techniques for surface treatment (Kirmali, Akin and Kapdan, 2013; El- Korashy and El-Refai, 2014; Saker, Ibrahim and Ozcan, 2013; Gomes et al., 2013).

Hydrofluoric acid (HF) was found to have insignificant effect on zirconia bonding due to its high crystalline content and lack of glass that HF dissolves to create micro porosities (Zandparsa et al., 2013). Moreover, tribochemical silica coating failed to cover the entire surface with silica (Saker, Ibrahim and Ozcan, 2013).

Another study showed that the highest bonding effectiveness to dental zirconia was achieved by combining mechanical pretreatment using tribochemical silica sandblasting and chemical pretreatment using a ceramic primer (Bielen et al., 2015; Inokoshi et al., 2013). Opposite to that, a study showed that the silica coverage resulting from the coating particles did not appear to be firmly attached to the hard Zirconia surface which may be considered a weak link for bonding (Cheung, Botelho and Matinlinna, 2014).

A couple of articles tackled laser surface treatment and its effect on bond strength. It was stated that Er:YAG laser did not give durable bond but $CO_2$ and Nd:YAG gave more durable bond. The authors justified this discrepancy by stating that zirconia had a low potential to absorb the laser energy that came from Er:YAG laser. Moreover, they still doubt the laser surface treatment because the laser irradiation may cause micro crack formation and ceramic subsurface destruction (Kasraei et al., 2015; Ural et al., 2010).

Recently, it was concluded that the preferred treatment method for zirconia is airborne-particle abrasion (APA) with $Al_2O_3$ (Zandparsa et al., 2013). Wegner and Kern said that a durable bond was achieved when they cemented air-abraded zirconia surface to resin cement containing (10-MDP) (Kim et al., 2015). It should be noted that as perfect as the surface treatment may get, contamination by saliva and blood may cause contamination of zirconia surface thus resulting in a decrease in bond strength (Kim et al., 2015). Because the most effective and useful cleaning method is APA (Kim et al., 2015), haphazard sandblasting of zirconia will cause micro cracks on the surface which may deteriorate restoration clinical performance (Zandparsa et al., 2013).

APA surface is a highly reactive surface. The problem of lab APA is that this sandblasted surface may get contaminated from careless handling in the lab or due to placing the sandblasted surface on the casts again (that were contaminated from a previous try in) (Aladağ et al., 2014; Zhang et al., 2010). Thus, chair-side application of APA may prevent lab contamination and ensure the protection of the highly reactive surface in addition to controlling the APA parameters.

A question worth asking, can the chair-side APA be more efficient substitute to lab sandblasting? The null hypothesis of this study was that there will be no significant difference between chair-side and laboratory APA.

## MATERIALS AND METHODS

### Specimen grouping

The study was divided into 2 groups (n=36 each): laboratory (L) and chair-side (C) according to APA application. Each group was further divided into 3 subgroups according to type of zirconia used.

### Specimen preparation

### Zirconia ceramic specimens

Using AUTOCAD (Autodesk, mac,2017) a 3D cuboid of 8x8mm and thickness of 3mm was created. The design was drawn and exported as STL (standard triangulation language) file to CAD/CAM software (Dwos software, Weiland Dental). A block of each material was mounted in the milling machine (Weiland Zenostar coping, Weiland Dental) where 24 cuboids were milled from each zirconia block in dry mode.

After milling, each cuboid was cleaned using jets of air, placed in ultrasonic solution for 20 secs and left to dry and then placed in ceramic oven for sintering according to manufacturer directions: temperature of 1550˚c with increasing rate of 10˚c/min, holding time 2 hours then decreasing temperature rate is 10˚c/min. The cuboids were randomly distributed among the groups.

### Fabrication of Resin blocks

Transparent plexi frames of thickness 3mm was prepared by process of laser cutting. In the middle of this frame a cuboid of (6x6) was laser cut in order to standardize the size of resin blocks obtained from the plexi. Another transparent plexi frame was cut to act as a floor or wall. The 2 plexis were put above each other. Composite was then injected in (6x6) hole created in the middle of plexi and supported below by the other plexi. A histology glass slide was put to insure a flat composite surface on top and then light cured. After curing, the 2 plexis were separated from each other and composite was pushed from the hole created.

### Air Particle Abrasion

In each subgroup of group (L) specimens were randomly distributed among 3 lab practioners and in each subgroup of group (C) specimens were randomly distributed among 3 prosthodontists.

### Lab jig

A jig was constructed to standardize an angle of 60° and 1cm distance between application tip and zirconia surface. The jig was given to lab to standardize parameters while APA. Zirconia cuboids of each type was APA with $Al_2O_3$ (50$\mu$m) as listed in sub grouping at pressure 2 Bar for 20 secs in a brushing motion (Su et al., 2015; Inokoshi and Meerbeek).

### Chair-side jig

The chair-side jig was constructed in the same way as laboratory jig with a difference that the APA machine is fixed to the jig. The jig was designed in a way where $Al_2O_3$ will fall from the machine on the zirconia surface by an angle 60°. The distance between the application tip and the surface was 1cm to ensure standardization of all APA parameters.

### Zirconia holder

A holder for zirconia cuboids was designed so that zirconia cubes can move freely under application tip while maintaining distance between them.. This holder was cut having same zirconia cube dimensions and thickness keeping zirconia surface flushed with top of holder, keeping a distance of 1 cm and angle of 60° from the application tip.

**Cementation**

Once APA was done, all cuboids were collected and placed in ultrasonic machine for 40 secs. After all cuboids being dried using jets of air, zirconia primer (monobond plus) was applied to the APA surface using micro brush. The primer was left for 10 secs and then thinned out by air. A bond was applied on the fitting surface of composite cuboids. Self-adhesive resin cement (Maxcem elite, KERR) was auto mixed and applied to the primed surface. Composite resin cuboids were placed over zirconia cuboids under 5kg for 6 mins in p to be cemented in exact position. All specimens were immersed in water at 37° for 24 hours.

**Specimen testing**

All specimens were stored in distilled water at 37° for 24 hours. After thermocycling for 1000 cycle, shear bond strength was measured for each specimen by aid of universal testing machine (Instron 8874, Instron Corp.) at a crosshead speed of 0.5 mm/min. Failure load of each specimen was recorded in Newtons and SBS was calculated as follows: SBS (MPa) = load (N)/area(mm2). A framework to hold the specimens was fabricated. The plexi was laser cut with a dimension of 8x6x8 and cemented to another plexi to act as a floor. They were put longitudinally so that tip would fall on the interface until sudden drop of load.

Fig. (1) Custom made chair side jig.


Fig. (2) Testing machine falling on interface.

**Statistical analysis**

Kolmogorov-Smirnov normality test was applied to evaluate the normality of the data distributions. One-way ANOVA test and T-student test were conducted to investigate significant difference between groups. Bonferroni was applied as a post-hoc test.

All statistical analysis was conducted using SPSS v.17 (BM Corp; Armonk, NY). Charts were created using Microsoft Excel 2013. An alpha level of 0.05 was used as a decision point for statistical significance.

## RESULTS

Results were divided into 2 sections according to parameter researched:

1. **Effect of APA Application on SBS values according to Zirconia Type:**

Comparing between 3 types of zirconia (ST, TT, HT) using T-students test, the test results showed that there were significant differences between LST and CST (P=0.000) and between LHT and CHT (P=0.039). TT subgroups showed no significant difference (P=0.710) (Table 1).

2. **Effect of APA Application on SBS values:**

T-student test was applied to compare between Lab group and chair-side group (Table 2). The results showed that there were significant differences between Lab and Chair-side groups (P=0.01).

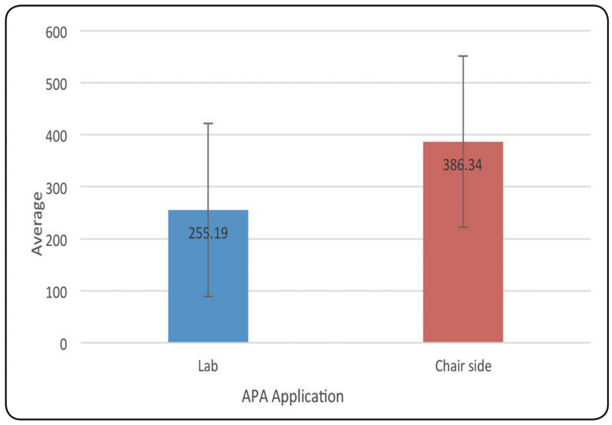


Fig. (3) Mean SPS values recorded according to APA Application.

## DISCUSSION

The achievement of ceramic restoration that fits perfectly esthetic demands of a patient is an important factor for success of the treatment. Longevity of any restoration relies on perfect adhesion between tooth and restoration among other factors. Adhesion not only relies on material but also on tiny steps that were utilized during bonding procedures. Zirconia, being resistant to chemical etching, is sensitive and not forgiving towards bonding steps.

A lot of procedural steps were implemented in current study in order to standardize the laboratory steps to perfectly serve the purpose of the study.

True that natural teeth are best to be used to bond

Table (1) Descriptive statistics of SBS according to Zirconia type with T-student test results.

| Zirconia Type | APA Application | N | Mean | Std. Dev. | P-Value |
|---|---|---|---|---|---|
| ST | Lab | 12 | 6.00 | 2.48 | P=0.00* |
| | Chair-side | 12 | 11.38 | 3.42 | |
| TT | Lab | 12 | 7.40 | 5.75 | P=0.710 |
| | Chair-side | 12 | 8.13 | 3.40 | |
| HT | Lab | 12 | 7.87 | 5.17 | P=0.039* |
| | Chair-side | 12 | 12.69 | 5.59 | |

****Significant difference at*** $P \leq 0.05$

zirconia for SBS test. The problem was that each natural tooth has a history regarding to age of patient, degree of calcification, dentinal tubules count, amount of moisture content, date of extraction, etc. All these factors are extremely difficult to control and standardize and thus may affect the integrity of results. That's why in current study composite cuboids were used instead of natural teeth as they are having nearly same modulus of elasticity. It is also beneficial due to uniform structure of composite. Also, in most of the cases we have composite build up or fiber posts in our preparation.

Plexi-frames were fabricated to standardize the size and to perfectly cement all specimens in exact position.

APA parameters were selected based on a previous study. The 72 specimens were subjected to same parameters but divided into laboratory and chair-side. A previous study tested effect of APA protocol on zirconia specimens. They used 50µm $Al_2O_3$ and other particle sizes and they concluded that sandblasting zirconia by 50µm $Al_2O_3$ is capable of producing more roughness when compared to other particle size (Özcan et al., 2013).

Moreover, Moon et al. studied how different APA protocols affect shear bond strength. In his study, he changed $Al_2O_3$ particles, pressure, angulations and timing. Authors were able to conclude that 50µm at 4 bars for 20 secs is capable of giving highest shear bond strength (Moon et al., 2016).

done till present, no studies were done till present to compare laboratory and chair-side APA using 50µm $Al_2O_3$ particle. In a study done in 2008, authors compared 4 groups where 3 groups were APA with 50µm $Al_2O_3$ particle followed by 3 different primers while the fourth group used the laboratory abrasion of particle size 100µm followed by silica and found no significant difference. Unfortunately, changing particle size resulted in inability to compare it to present study.

According to results of the current study for both laboratory and chair-side APA methods, mean shear bond strengths to the zirconia material tested were significantly different for ST and HT while TT showed no difference.

According to results, chair-side APA showed higher mean values than laboratory. This may be attributed to several reasons. Maybe the APA parameters in lab were applied inaccurately which made this difference in results. Distance was maybe greater than 1 cm which made $Al_2O_3$ particle deflect away from the surface.

In a study done by Zeighami et al., authors studied surface roughness of zirconia after APA by changing distances. At a distance of 15mm, specimens showed more surface roughness and higher potentials in bonding when compared to specimens sandblasted at 25 mm distance (Zeighami et al., 2017).

Time is also a reason. Su et al. studied various APA conditions and its effect on the interface between zirconia and resin cement. In the study, they tackled APA time where it varied from 7, 14 and 21 secs. They concluded that APA for 21 secs improved bond strength of zirconia more than the other time factors (Su et al., 2015).

Contamination of specimens may also be a variable worth researching. APA surface is a highly reactive surface where any careless handling of zirconia may cause contamination of the surface and subsequently affect bond strength negatively. When APA the chair-side specimens, every blasted specimen was held carefully without touching the zirconia treated surface and kept alone in autoclave plastic bag. Lab specimens of every practioner of different zirconia types were collected in pouches; this might cause contamination if not packed directly without touching any contaminated surface (Aladağ et al., 2014; Zhang et al., 2010).

In both groups TT didn't show any significant difference. Viewing results of chair-side TT, one can recognize how close the results are to lab HT and ST and how far it is from chair-side HT and ST. Composition of TT is different from other zirconia content which might allow us to think that maybe TT needs other APA parameters. According to manufacturer, HT zirconia is the strongest among all zirconia which makes it suitable for posterior use. Grain size, porosity, grain boundaries and degree of crystallinity are the main factors which affect material properties (Fathy et al, 2015).

The null hypothesis of present study was rejected as there was significant difference among tested groups.

## CONCLUSIONS

Within the limitations of the present in-vitro study, the following could be concluded:

1. Chair-side APA may be more reliable substitute for lab sandblasting..
2. Shear bond strength for ST and HT was higher when using chair-side APA so chair-side APA could be a good choice rather than laboratory.
3. Shear bond strength of TT zirconia was approximately the same for both types of APA.

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