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EFFECT OF SILICA COATING WITH DIFFERENT LUTING CEMENTS ON THE BOND STRENGTH OF A ZIRCONIA BASED CERAMIC

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ABSTRACT

Statement of the problem: Debonding is a common cause of failure in zirconia-based restorations. Despite the use of resin cements and surface treatments, the rate of success remains to be questioned.

Purpose: The purpose of this study was to evaluate the effect of surface treatment using a silica coating (Co-Jet) method with different luting cements on the shear bond strength to zirconia samples. The hypothesis was that surface treatment with different luting cements will influence the bond strength at the ceramic-cement interface.

Materials and Methods: In this study 30 zirconia samples were constructed and underwent surface treatment using a silica coating method (Co-Jet system). Zirconia samples were then bonded to composite samples using different luting agents (Bifix QM, Panavia 2.0 and Multilink Automix). Samples underwent a thermocycling aging process before shear bond strength was tested.

Results: The highest shear bond strength was recorded with the Panavia 2.0 group while the lowest was with the Bifix QM group.

Conclusions: Within the limitations of this study, the use of a Co-Jet sand silica coating system with Panavia 2.0 showed superior bond strength than the other luting cements.

KEY WORDS*:* Zirconia; resin cement, silica coating, thermocylcing, shear bond strength

INTRODUCTION

Porcelain fused to metal has been on the top of the most durable esthetic restoration available to the dentist. Now this reign has ended. Ceramic materials can now be used without an underlying metal coping, giving better light transmission and therefore esthetics. These materials are either a silica based, or non-silica based in nature. Silica based ceramics have the advantage of being able to be etched with hydrofluoric acid, followed by accepting a saline coupling agent to form a reliable bond between the ceramic and resin/tooth junction. [(1)]

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Non silica-based ceramics like zirconia which have a flexural strength (900-1200 MPa), therefore can be used in posterior regions safely, can neither be etched with hydrofluoric acid nor bind to silane, therefore making the bond strength weaker than silica based ceramics. [2]

Surface treatment is usually recommended by most authors in a variety of materials to improve the bond strength. This is done to increase the surface energy, producing a rougher surface, hence more surface area, with irregularities for micro-mechanical retention. This can be accomplished with air particle abrasion. [3]

Another method is using a silica coating method that produces the rough surface but also deposits silica particle on the ceramic surface that can bind with the resin cement. This is known as Tribo-chemistry. [4] The tribochemical silica coating system that can be done in the dental office is the CoJet system by 3M ESPE. [5,6]

Resin cements are the luting cement of choice when cementing ceramic restorations. They give better retention, stability, strengthen the restoration and can be translucent as not to alter the esthetics. [7] Chemical bonds occur between the resin and the ceramic restoration depending on the type of the functional group. The manufacturers of the resin cements claim that their bond strength is stronger and more durable than their competitors.

Bond strength is defined as the maximum load per unit area that causes failure on or near the bonded interface of the substrate and adherent. There are several methods to test the bond strength, shear, tensile, micro-tensile and micro-shear tests. [8] Bond strength is influenced by many factors. One of these is the fluctuation from hot and cold in the oral cavity. [9] To simulate this, researchers use a thermocycling device, although the number of cycles and what it corresponds to intra-orally is still debatable.

MATERIALS AND METHODS

A single blank disc of Bruxzir zirconia (Glidewell Dental Lab. USA) was used to produce all the samples. They were cut by a microsaw to obtain 30 square samples of 10mm × 10 mm. The samples were cleaned in an ultrasonic water bath filled with distilled water to remove any debris, then dried under a heat lamp. The zirconia samples were placed in a sintering furnace according to the manufacturer's instruction to obtain fully crystalized zirconia samples.

A custom-made mold was used to fabricate the 30 composite samples. The mold consisted of an outer assembling copper ring, while the inner part a split Teflon square with dimensions 5×6mm surface area and 3mm in height. A transparent thin glass slab was placed under the mold and the composite (Z250, 3MESPE) was densely packed with a plastic instrument. Then another thin glass slab was above the mold and the composite was initially cured by a light curing device for 40 secs on each side. Both glass slab was removed and another curing time of 20 sec was done to insure complete polymerization. Excess marginal composite was removed using a micro-motor. Samples were checked visually for any defects and a caliber for standardization.

Sample Grouping: the total of 30 samples were divided into 3 groups (10 each) according to the type of cement to be used: Group 1 Bifix QM (VOCO, Germany); Group 2 Panavia 2.0 (Kuraray Noritake Dental, Japan); and Group 3 Multilink Auto mix (Ivoclar-Vivadent, Liechtenstein).

All the zirconia samples were surface treated using an intra-oral air abrasion device which was placed in a custom made holding device to standardize the distance between the nozzle and zirconia sample (10mm) and at a 90° angle, Fig. (1). The intra-oral air abrasion device was filled with 30μ silica coated alumina particles (CoJet sand). The pressure was set at 2.8 bar and the blast time was 15 seconds as recommended by the manufacturer.

Bonding of samples: For Group 1, a ceramic bond was applied using a micro-brush and left to dry for 60 sec. Excess was removed with an oil free gentle air stream. The Bifix QM cement was applied directly onto the zirconia sample. The composite was centralized over the sample and a 5kg load was applied to insure consistent seating pressure. After 30 seconds excess cement was removed, an oxygen protective gel was applied over the margins and light cured for 40 secs from each surface.

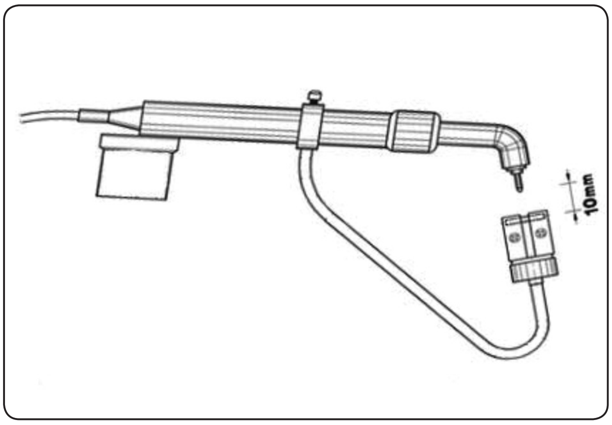

Fig. (1) Custom made holding device to standardize nozzle to sample distance.

For Group 2, Mono-bond N was applied to the zirconia surface with a micro-brush and left for 60 sec. As in group 1 excess bond was removed, cement placed, centralized and cured.

For Group 3, Clearfil ceramic primer was applied with a microbrush and also left for 60 seconds. Equal parts of paste A and paste B were mixed with a plastic spatula on a mixing pad for 20 seconds then applied to the zirconia sample and the previous steps as before were done.

Thermocycling of samples: After cementation of the zirconia-composite samples, they were stored for 24 hours in distilled water, then submitted to thermocycling process (Robota automated thermal cycle, Turkey). This was 1000 thermocycles at temperature of between 5°C and 55°C, with a 30 sec dwell time and 10 sec transfer time.

Shear bond strength testing: A universal testing machine with a mono-beveled chisel rod was used to test the zirconia/composite samples. A load of 5kg and a cross head speed of 0.5mm/min was applied. The load required for debonding was recorded in Newton.

Shear bond strength was calculated according to the following equation:

$$= F/A$$

Where τ is shear bond strength in MPa; F is force at failure; A is the bonding area in mm.

RESULTS

The results showed that there was a significant difference between all the tested groups, Tab. (1) and Fig. (2). The highest shear bond strength values were recorded with the Panavia group (13.39 ± 1 MPa), followed by the Multilink Automix group (10.4 ± 1.02 MPa), while the least value was with the Bifix QM group (8.25 ± 0.76 MPa).

TABLE (1): Shear bond strength values (MPa) with SD of the resin cements used.

Resin Cement	Shear bond strength (MPa)
Grp 1: Bifix QM	8.25 ± 0.76 [c]
Grp 2: Panavia F 2.0	13.39 ± 1 [a]
Grp 3: Multilink Automix	10.4 ± 1.02 [b]

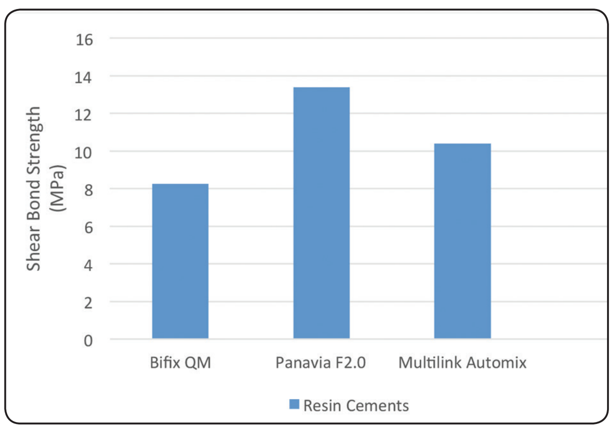

Fig. (2): Bar chart of resin cements showing their respective Shear bond strength.

DISCUSSION

The demand of zirconia-based restoration is on the rise between dental practioners due to its high mechanical properties, esthetics and biocompatibility. [1]

Literature has demonstrated that there is a weak link between the cement and the fitting surface due to inability of the zirconia to be etched and silinated like glass ceramics. [10] This in-vitro study investigated the effect of silica coating with different luting cements on the bond strength of a zirconia-based ceramic.

Many authors advocated the use of silica coating to increase the bond strength between zirconia and resin cements by roughening and embedding silica particles on the surface. These silica particles bond chemically with silane upon its application. [11]

The resin cements used in this study were dual cured in nature as zirconia is opaque which will prevent polymerization of light cured resin cements. The three cements used, each had a distinct monomer content. Bifix QM resin has a Bis-GMA adhesive monomer. Panavia F 2.0 resin contains an MDP adhesive monomer; while Multilink Automix has a phosphoric acid acrylate monomer.

Thermocycling was used in this study owing to the fact that thermocycling results in the highest clinically relevant stress when testing durability of resin bond and affects the bond strength between zirconia and resin cement more than water storage at a constant temperature. [12]

The shear bond strength test done in this study is commonly used in the literature as it is easily done, fast and gives a good indication about the behavior of cemented restorations to lateral and axial forces. [13,14]

The results of this study showed that there was a significant difference between the three tested cements. The highest shear bond strength was with the Panavia group. This can be attributed to the ability of the phosphate ester monomer in the MDP to bond directly to zirconia oxide. The results of this study were in agreement with Seto et al [15] and Ozcan et al. [16]

Bifix QM had the lowest recorded shear bond strength values. This can be explained by the possible disadvantages of Bis GMA molecule. These are high viscosity, water sorption and a low degree of conversion. Manufacturer incorporated diluents to try to overcome of high viscosity, but this resulted in higher shrinkage stresses. [17,18]

The minimal clinically acceptable bond strength value for a successful service in the oral cavity was reported by Akgungor et al [19] and Behr et al [20], to be 10 MPa. Bifix QM cement dropped below this level while the Multicore Automix was just at the level.

According to the results of this in-vitro study, the tribochemical silica coating followed by using a resin cement containing MDP would be the best protocol for bonding zirconia-based restorations.

However longer thermocycling and dynamic loading may change these recommended protocols. Also, intra-oral conditions are more dynamic and complex than in-vitro studies, but these studies are vital to learn about how a material can endure before it is placed intra-orally.

CONCLUSION

Within the limitations of this study, the following recommendation can be made:

After silica coating of zirconia, Panavia F 2.0 resin cement showed the highest shear bond strength when compared to Multilink Automix and Bifix QM resin cements.

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