EFFECT OF DIFFERENT SURFACE TREATMENTS ON THE BONDS STRENGTH OF A RESIN CEMENT IN ZIRCONIA FRAMEWORKS

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Abstract

To compare the shear bond in zirconia blocks using different surface treatments with adhesive materials in different test environments.

Sixty blocks of zirconia cut and sintered Cercon art 7x7x3 mm and thirty blocks 4x4x3 mm were separated in three groups: 1. no treatment (control), 2. alumina airbone-particle abrasion, 3. CoJet airbone-particle abrasion (silica coating with 30 μm silica-modified alumina particles). After surface treatment, blocks were bonded against acid-etched resin blocks + silane + RelyX U200. Templates were divided again in three groups and stored in three different environments: 1. dry stored, 2. In 37°C distilled water for ten days, 3. Thermocycled (10,000 cycles of 5°C and 55°C). All templates were subjeted to shear bond strength test with instron machine. The data was analyzed with Systat software for Windows for one-way ANOVA and two-way Scheffe test. Failure mode was observed and analyzed by optic microscope (OM).

CoJet airborne-particle abrasion resulted in higher shear bond strength than those in other groups, while no significant difference existed between the specimens which were treated with alumina airbone-particle abrasion and CoJet airbone-particle abrasion, but the CoJet treatment was significantly higher than no treatment ($p<0.05$). In all three environments CoJet airbone-particle abrasion treatment obtained higher values. No cohesive failures were observed by OM in any group.

The combination of tribochemical silica coating (CoJet, 3M) with silane coupling can improve the bond of zirconia when self-adhesive resin cement is used and it is recommended as a pre-treatment to increase zirconia retention.

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Introduction

Ceramics are very common material to use in aesthetic dentistry. They have different good characteristics, like translucent, aesthetic, good resistance, biocompatibility, color stability, good mechanic resistance, etc.

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Partially stabilized tetragonal zirconia (Y-TZP) ceramics are frequently used in aesthetic dentistry for ceramic crowns, fixed partial dentures and veneers [1,2]. Clinical success of aesthetic restorations depends upon not only on aesthetic results or optimal marginal adaptation, but also bonding durability.

To achieve good bonding durability of the ceramic frameworks, surface area of the bonding ceramic must be improved and an activated [3,4]. Many surface-treatment methods have been attempted for dental ceramics, including etching. Etching is not available for Y-TZP because it has not a glass-phase and it has a higher crystalline content [5,6].

Airbone-particle abrasion is a suitable

method to increase surface energy and produce an active surface for dental bond. These rough surfaces contribute to produce micromechanical interlocks of the bonding interface [3,4,7,8]. Tribochemical (TBC) treatment by CoJet (3M ESPE) is also available for YTZP to improve shear bond strength. Silica-coated alumina particles are sandblasted at low pressure, and ceramic surfaces chemically modified with silica by the TBC mechanism. Silane treatment has also been used to increase bonding strength. Many investigations have reported that a functional monomer of 10-methacrylixydecyl dihydrogen phosphate (MDP) has better adhesive results for high-strength core ceramics such as alumina and Y-TZP5 [4,8,9]. In particular, a combination of MDP monomer and CoJet airbone-particle abrasion treatment is expected to generate a stable and durable bond strength of self adhesive cement to Y-TZP [3,4,10,11]. The effect of combination treatment for Y-TZP has not been investigated. The aim of the present study was to compare the shear bond in zirconia blocks using different surface treatments with adhesive materials in different test environments.

Materials and Methods

Templates

Zirconia blocks (60 templates 7×7×3 mm and 30 templates 4x4x3 mm) Figure 1, were cut from pre-sintered green zirconia blocks (Cercon) using a diamond cutting saw (Isomet 1000, Buehler, Lake Bluff, IL, USA).

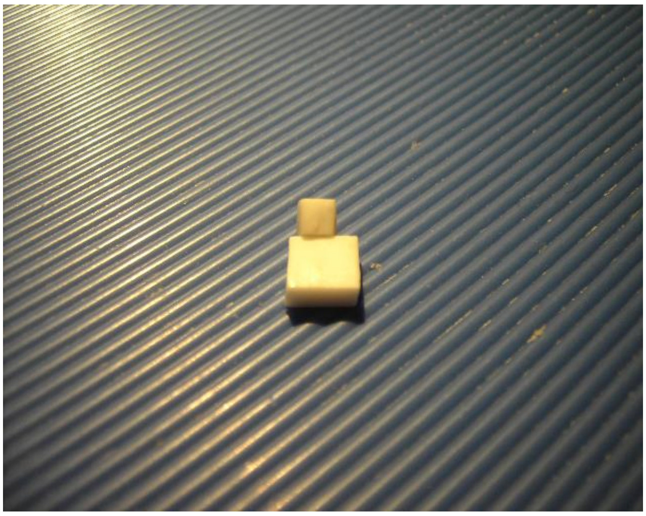

Figure 1. Zirconia templates 7x7x3 mm and 4x4x3 mm.

Specimen surfaces were then polished by a 1.0- μm alumina abrasive paper (P/N AFP 045-35 LOT11245; South Bay Technology Incorporated, CA, USA) to achieve surface roughness of 0.15 μm. After polishing, all templates were sintered at 1,350°C for 2 h. Templates were cleaned ultrasonically in acetone solution for 5 min, and then dried by airbone-particle blasting.

Treatment and Modification of the Surface

Two surface treatments were used in this study: 1. Templates without surface treatment were used as a control surface; 2. Alumina airbone-particle abrasion treatment (AT) with a mean particle size of 25 μm (WA25, Heraeus Kulzer, Hanau, Germany) was blasted onto the surface of zirconia specimens at a pressure of 0.45 MPa (15 s/cm2) at a distance of 10 mm; and (3) TBC treatment (TT) using silica-coated alumina particles with a mean particle size of 30 μm (CoJet™, 3M ESPE) enabled these particles to be blasted onto the bonding surface of zirconia specimens at a pressure of 0.45 MPa (15 s/cm2) and a distance of 10 mm.

Preparation of Resin Blocks

It was used a two gum cast of 7x7 mm and 4x4 mm and Cold curing resin (Z350, 3M ESPE) to prepare resin block for the bonding body test templates.

Primer and Luting Cements

It has been used Ultradent Silane (Dentsply) for each zirconia template and single bond universal adhesive (3M ESPE) to each resin block in all surface treatment.

Bonding Procedure

First, it has been applied silane to each zirconia template and adhesive to each resin block after the surface treatments and then air dried. After, mixed RelyX U200 cement paste was applied to the each zirconia template, and then pressed onto the resin block. The specimen was immediately loaded at 1 kgf by a constant loading device, and excess cement paste was removed. Cement was irradiated from four directions for 20 s for a total exposure time of 80 s using a light curing unit (Elipar S10, 3M ESPE). Intensity: 1200 Mw/cm2. Wave lenght: 430-489 nm.

Environment Storage

All templates bonded were divided in the different environment in this way: 30 zirconia blocks (10 control, 10 AT, 10 TT) in dry stored, 30 zirconia blocks (10 control, 10 AT, 10 TT) in 10 days of distilled water at 37°C and 30 zirconia blocks (10 control, 10 AT, 10 TT) for 10,000 cycles of thermocycled.

Shear Bond Test

The templates were mounted in acrylic tubes for the shear bond test Figure 2.

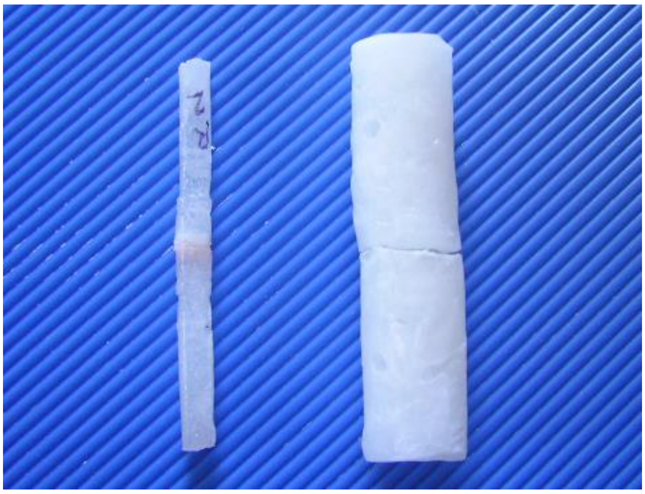

Figure 2. Acrylic tubes mounted with zirconia templates.

The shear bond test was carried out using a universal testing machine (Instron, Kawasaki, Japan) at a crosshead speed of 1.0 mm/min, Figure 3.

Figure 3. Universal testing machine (Instron, Kawasaki, Japan) with mounted templates.

Shear bond strength was measured in each bonding evaluation parameter for surface treatment. Results were ordered in Excel and values were transformed from KgF to MPa.

Statistical analyses mean values of shear bond strengths were analyzed by one-way ANOVA and two-way Scheffe's tests to determine significant difference (p>0.05) between surface treatments.

Results

The results of shear bond strength tests for the three surface conditions are listed in Table 1 and environment storage in table 2. For Scheffe's test results are listed in table 3. One-way ANOVA showed that the shear bond strengths were significantly affected by surface treatment in CoJet airbone-particle abrasion compared to control group (p=0.001). Shear bond strengths for environment and combination of surface treatment and environment were not significantly different (p>0.05).

Groups	n	x ± DS
Control	30	6.363 ± 1.101
AT	30	8.199 ± 2.599
TT	30	9.626 ± 2.039

Mean shear bond strengths and SD. Values in MPa.
*Abrasion treatment (AT) TBC treatment (TT).

Table 1. Surface treatments.

Environmet	n	x ± DS
Dry storage	30	8.426 ± 1.570
10 days distilled water	30	7.720 ± 2.002
Thermocycled	30	8.321 ± 3.374

Mean shear bond strengths and SD. Values in MPa.

Table 2. Environment storage.

Groups Environment	n	Control	n	AT	n	TT
Dry storage	10	6.800 ± 0.701	10	8.908 ± 1.285	10	9.570 ± 1.119
10 days distilled water	10	5.973 ± 0.409	10	7.705 ± 2.182	10	8.780 ± 1.918
Thermocycled	10	6.110 ± 1.768	10	7.884 ± 3.966	10	9.528 ± 2.777

Mean shear bond strengths and SD. Values in MPa.
*Abrasion treatment (AT) TBC treatment (TT). Values in MPa.

Table 3. Surface treatment and environment storage.

The fractured surface all templates could be clearly observed as cohesive failure (data not shown) because a large amount of resin luting cement was on this zirconia surface.

Discussion

Zirconia is a useful material for fabrication of an aesthetic prosthesis to withstand high loading. The present work compare the shear bond in zirconia blocks using different surface treatments with adhesive materials in different test environments. Zirconia is a less advantageous material for bonding to resin cements compared with other ceramics because of low surface energy and wettability[12]. Zirconia therefore needs treatment or modification of its surface to achieve durable bonding. Results showed that TBC treatment had higher bond strength compared with other surface conditions. TBC treatment had significant differences (p=0.001) compared with control group, but no significant differences for environment and with both together variables. Results were similar to other studies [13,14,15] where the TBC treatment increased bond strength. In this study results were lower in bond strength, may be for the adhesive methodology used.

Botinno et al.[13] shows that TBC surface treatment with increased bond strength, because silica particles would make micromechanic and chemical conditioning to zirconia surface. This chemical conditioning acts directly onto zirconia surface, acting between silica and silane molecules with triple bond (≡Si-O-Si≡). Moreover, alumina airbone-particle abrasión shows lower bond strength in doble bonds between alumina and silane (=Al-O-Si≡). In addition, this results shows chemical bond between MDP of the adhesive, silica and silane[16].

Monticelli et al.[17] confirm that previous result, explaining that CoJet makes a surface modification in micromechanical and chemical way with substrate to cement.

Furthermore, Motohiro Uo et al. [18] assert that surface treatment increase both surface to bond.

Özcan et al.[19] adds that different particle sizes not generated significant difference in bond strength of templates.

When we talk about environments, different studies [14,15,18,20-22] shows that results are similar to obtain in this work about water storage at 37°C and thermocycled. Those studies argued that surface treatment create surface irregularities, and those were minimal compared to blasted alloys, therefore, physic and chemical bond created with conventional BisGMA cements and zirconia would not resist water contact. Furthermore, silane alone not increase bond strength in zirconia surface without treatment. Botinno et al.[23] concluded that TBC treatment increase significantly initial bond strength between resin cement and zirconia frameworks.

TBC treatment has been reported to increase not only micromechanical retention, but to also produce a silica layer on the bonding surface, acting with silane and resin cement [24]. TBC treatment conveys the mechanical energy of sandblasting to the treated surface in the form of kinetic energy. In general, TBC treatment does not produce a temperature rise, and its effects are influenced at the atomic and molecular levels[25].

In this study, it has been used MDP monomer for adhesive treatment. Several studies reported that MDP showed excellent bonding to not only non-precious metals, but also ceramics because the hydrogen group in this monomer reacted chemically with the hydrogen layer [24,26]. The application of MDP monomer and TBC treatment has been expected to generate a stable and durable bond strength between zirconia and resin cements [3,4,24,26].

Shimakura et al. [27] reported that combination treatment using MDP after TBC treatment enhanced bond strength and bond durability for silica-based glass ceramics. In this study, it has been investigated the effect of the combination treatment using MDP monomer.

The present study shows that TBC treatment increase bond strength compared with control group, whereas no significant differences were appreciated in different environments.

The findings of the present study suggest that combination treatment using MDP monomer was sufficient to produce durable bond strength for zirconia. Further study is needed to analyze the bonding interface mechanical and chemically and to evaluate the behavior of functional monomers.

Conclusions

After completing the present study, the following conclusions could be drawn:

1. Treatment by TBC increases bond strength in zirconia frameworks compared with control templates.

2. No significant differences between TBC and Alumina treatments in zirconia templates.

Clinical Relevance

Clinicians may increase the lifetime of their zirconia aesthetic treatment by choosing the right materials for adhesive cementation.

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Declaration of Interest

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