Shear Bond Strength of Veneering Porcelain to Zirconia After Argon Plasma Treatment

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Purpose: The aim of this study was to investigate if argon plasma cleaning increases the shear bond strength between zirconia and veneering ceramic surfaces. ***Materials and Methods:*** Ninety tablets of densely sintered yttria-stabilized tetragonal zirconia polycrystal were divided into three groups according to cleaning treatment (steam cleaning or plasma of Argon for 375 or 750 seconds). Groups were divided into two subgroups according to the application of a ceramic liner (A = liner, B = no liner). ***Results:*** Within subgroup A, argon plasma cleaning significantly decreased shear bond strength. In subgroup B, the plasma treatment increased the shear bond strength, but the differences were not statistically significant. Subgroup A demonstrated lower shear bond strength compared to subgroup B. ***Conclusions:*** Argon plasma cleaning was suggested to improve the bond between ceramic and zirconia surfaces; however, when plasma cleaning was followed by a glassy liner application, the veneering ceramic/zirconia bond was significantly reduced. *Int J Prosthodont 2014;27:137–139. doi: 10.11607/ijp.3722*

In zirconia-based restorations, ceramic chipping and fracturing has been reported at higher rates compared with metal-ceramic systems.[1] The core-veneer bond strength may be affected by several factors, including[2] the coefficient of thermal expansion mismatch between zirconia and veneer material, core surface roughness, transformation of zirconia crystals at the core-veneer interface, lack of oxide layer at the zirconia-ceramic interface, wetting properties, and firing shrinkage of the veneering ceramics.

Different strategies have been suggested to enhance core-veneer link.[3] These include anatomical framework design, sandblasting, tribochemical treatment, hydrophilic bonding, hydrofluoric acid treatment, and powder coating. Some of these techniques could be detrimental for the zirconia properties since they could promote the formation of a monoclinic phase.

Recently, plasma treatment of zirconia surfaces was shown to improve composite adhesion to zirconia cores by removing contaminants and creating polar groups (surface activation). Accordingly, the purpose of this study was to evaluate the shear bond strength of veneering ceramic to zirconia after argon plasma treatment. The null hypothesis was that argon plasma does not affect the shear bond strength between zirconia and ceramic.

Materials and Methods

Ninety tablets of densely sintered yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) zirconia (ZrO_2/Y_2O_3/Al_2O_3) were made by computer-aided design/computer-assisted manufacture (Echo, Sweden-Martina) and sintered.

The tablets were randomly distributed into three groups according to the surface cleaning treatment: steaming (group 1), plasma of Argon for 375 seconds (group 2), and plasma of Argon for 750 seconds (group 3).

Plasma cleaning treatment was performed in a plasma reactor (Yocto, Diener) using argon plasma at 75 W of power and –10 MPa of pressure.

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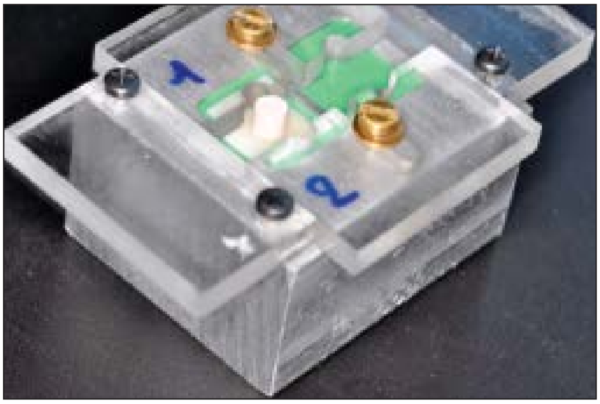

Fig 1 Ceramic cylinder showing placement within the mold.

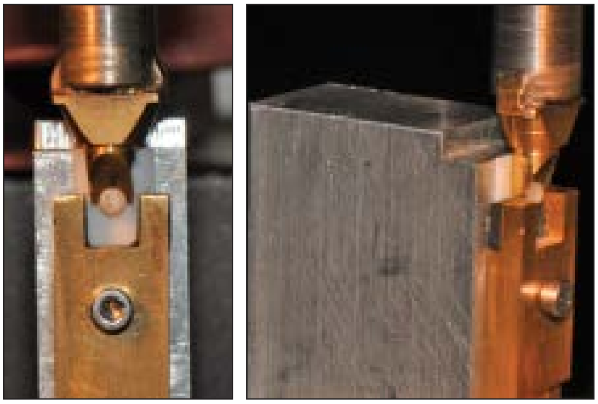

Fig 2 The shear bond strength testing device under the Instron machine.

Table 1 Test and control groups

Group	Cleaning treatment	Ceramic liner
1A (control)	Steam cleaned at 7-bar pressure	Yes
2A	Plasma cleaned for 375 s	Yes
3A	Plasma cleaned for 750 s	Yes
1B (control)	Steam cleaned at 7-bar pressure	No
2B	Plasma cleaned for 375 s	No
3B	Plasma cleaned for 750 s	No

Within these groups, two subgroups were defined according to the application of a ceramic liner: subgroup A (liner) and subgroup B (no liner) (Table 1).

After surface treatment, A subgroups were layered with a ceramic liner (IPS e.max ZirLiner, Ivoclar Vivadent), while subgroup B specimens were not.

All specimens were placed in a standardized mold with a 3.3-mm-diameter cavity, according to the ISO 11405 (Fig 1), in which the glass-ceramic veneer (IPS Emax Ceram, Ivoclar Vivadent) was condensed. Layered zirconia cylinders were fired in two separate firings.

After, all groups underwent a shear bond strength test. Specimens were prepared following the ISO 11405 standard by a blind operator. The shear bond strength test was performed with an Instron machine (Model 4465) with a 0.5 kN load cell at a descending speed of 0.5 mm/minute at 23°C room temperature until debonding (Fig 2).

The ultimate load to failure was recorded, and the fractured specimens were then etched with fluoridric acid and observed under a stereomicroscope (Wild M10, Leica) to determine if the failure mode was adhesive (interfacial), cohesive, or mixed.

Data were analyzed with one-way analysis of variance (ANOVA) and multiple comparison Neuman-Keuls test.

Results

Shear bond strength values in A subgroups were lower than in B subgroups (Table 2). Plasma cleaning showed contrasting effects depending on the use of a ceramic liner: in A subgroups, shear bond strength significantly decreased, whereas when the liner was not applied, shear bond strength values improved.

Group 1A presented a shear bond strength value of 27.92 MPa, whereas groups 2A and 3A presented values of 19.5 and 23.48 MPa, respectively.

Shear bond strength values in A subgroups were lower than in B subgroups (Table 2a).

In B subgroups, plasma cleaning promoted higher shear bond strength values compared with the control group (Table 2b). However, differences were not statistically significant due to a wide SD in comparison to the magnitude of the plasma effect.

In A subgroups, failures were mostly cohesive (Fig 3), while in B subgroups, failures were mixed adhesive/cohesive.

Discussion

The shear bond strength test for brittle materials has several limitations in respect to real clinical situations; nevertheless, it is one of the most widely used methods to test the interfacial strength of dental materials. As a result, shear bond strength results should be interpreted with caution.

The zirconia tested in this study showed shear bond strength values similar to the threshold values suggested for metal-ceramic assemblies,[4] except in the group where the liner was used after plasma cleaning. A possible explanation for this phenomenon might be that the increased wettability of zirconia has changed the solid/liquid phases distribution within the liner layer, determining a weakening in the liner bulk. In fact, the majority of failures of the liner-coated

Table 2a Shear Bond Strength Values (MPa) Recorded in Subgroup A

Group	n	Mean	SD	Significance*
1A (control)	15	27.9	4.06	A
2A (plasma for 375 s)	15	19.5	4.55	B
3A (plasma for 750 s)	15	23.5	4.93	C

*Groups connected by different letters indicate a statistically significant difference (Neuman-Keuls multiple comparison test at $\alpha \leq .05$).

Table 2b Shear Bond Strength Values (MPa) Recorded in Subgroup B*

Group	n	Mean	SD
1B (control)	15	31.0	5.72
2B (plasma for 375 s)	15	33.9	5.83
3B (plasma for 750 s)	15	32.0	3.85

*When veneering ceramic is applied directly to the zirconia surface, the plasma exposure seems to slightly increase the shear bond strength values, although the difference is not statistically significant (one-way ANOVA: F = 1.20; P = .310).

Fig 3 Specimen no. 7 belonging to subgroup 2A, treated for 375 seconds with plasma. The acid-etched, dull white surface reveals that zirconia is still covered by a glassy liner fractured cohesively, representing the weakness of the liner due to the plasma treatment. The black mark indicates the up-to-down force direction.

specimens were cohesive, and zirconia was often still covered by liner remnants.

Conversly, when liner was not used, shear bond strength in plasma groups was higher than in the steamed group. Adhesive and mixed failures might confirm a better distribution of ceramic layers.

Since A subgroups showed lower shear bond strength values, the results of this study question whether the glassy liner is necessary to create a stronger connection between zirconia and veneering ceramic. To confirm the outcomes of the present research, further studies are required.

Conclusions

Argon plasma cleaning was suggested for improving the bond between ceramic and zirconia surfaces; however, when plasma cleaning was followed by a glassy liner application, the veneering ceramic/zirconia bond was significantly reduced.

Acknowledgment

The authors reported no conflicts of interest related to this study.

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