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Short Communication

Effect of surface treatment and liner material on the adhesion between veneering ceramic and zirconia

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ABSTRACT

Fully sintered zirconia blocks, each with one polished surface, were treated with one of the followings: 1) no treatment, 2) airborne-particle abrasion with 50 μm alumina, and 3) airborne-particle abrasion with 125 μm alumina. Before veneering with glass ceramic, either liner A or liner B were applied on the treated surfaces. All veneered blocks were subjected to shear force in a universal testing machine. For the groups with liner A, irrespective of the particle size, air abrasion on Y-TZP surfaces provided greater bond strength than polishing. Application of liner B on an abraded zirconia surface yielded no significant influence on the adhesion. In addition, specimens with liner A showed higher bond strength than those with liner B, if applied on roughened surfaces. Fractured surfaces were observed as mixed patterns in all groups. For the liner A, surface treatment was helpful in bonding with veneering ceramic, while it was ineffective for the liner B.

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1. Introduction

Yttrium oxide partially stabilized tetragonal zirconia (Y-TZP) is used as the core material in all-ceramic restorations because of its biocompatibility, high flexural strength, and distinctive fracture toughness (Evans, 1990). The main reported complications of porcelain-veneered Y-TZP fixed dental prostheses in clinical dentistry are: delamination of the veneering porcelain with exposure of the core structure,

chip-off fracture of the veneer ceramic, and fracture of the zirconia substructure (Raigrodski et al., 2006; Sailer et al., 2006; Vult von Steyern et al., 2006). A recent series of studies on ceramic-veneered zirconia restorations report a 25% chip-off fracture rate after 31 months of follow-up. Other studies also report various failures, such as porcelain chipping, cracking, delamination, and large fracture (Guazzato et al., 2004; Raigrodski et al., 2006; Pittayachawan et al., 2007). Enhancement of the adhesion between the zirconia substrate

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and the veneering ceramic is essential for the clinical success of zirconia restorations (Fischer et al., 2008).

Adhesion between the veneering ceramic and zirconia is determined by several factors including chemical bonding, mechanical interlocking, wettability, and the degree of compressive stress in the veneer layer due to the mismatch of the coefficients of thermal expansion between the substrate and the veneer material (Isgro et al., 2003; De Jager et al., 2005). Many studies have evaluated various surface treatments for improving adhesion to veneering ceramics. Airborne particle abrasion increases surface roughness and produces undercuts for mechanical interlocking (Aboushelib et al., 2006). However, air abrasion results in a phase transition in the surface layer, transforming crystal structure from tetragonal to monoclinic (Kosmac et al., 2000). A liner is recommended to improve the contact between the materials; however, other studies report that a liner can weaken the degree of adhesion (Aboushelib et al., 2008; Tinschert et al., 2001; Fischer et al., 2010). For now, no standard method has been established for optimal adhesion between zirconia and veneering ceramics. This study compared the shear bond strength of zirconia substrate and veneering ceramic bonded with two different liners. The effect of surface abrasion by airborne particles on shear bond strength was also investigated. The null hypotheses tested are: (1) there is no difference between the liner materials in shear bond strength of zirconia to veneering ceramic, and (2) the surface treatment does not influence the adhesion of zirconia to veneering ceramic with both liner materials.

2. Materials and methods

The manufacturers' information and materials investigated in this study are presented in Table 1. Pre-sintered Y-TZP blocks (ZirBlank-PS) were prepared and fully sintered at 1500 °C for 2 h in a furnace (Austromat Basic). After firing, one square face of each cuboidal block (15 mm × 15 mm × 10 mm) was polished and cleaned in an ultrasonic bath with ethanol for 5 min. All specimens were divided into three groups according to the surface treatment: (1) no treatment (Group 1, control); (2) airborne-particle abrasion with alumina particles (Cobra; Renfert) of 50 µm diameter (Group 2); (3) airborne-particle abrasion using 125 µm alumina particles (Cobra; Renfert) (Group 3). Specimens of group 1 received no further surface treatment after cleansing. For groups 2 and 3,

abrasion was performed at a pressure of 0.2 MPa at a distance of 10 mm (Basic master; Renfert). A specimen was selected from each group and the surface measurement was carried out at three different locations using a confocal laser scanning microscope (LSM 5 Pa; Carl Zeiss). The arithmetic mean deviations of all surface height values (S_a) were obtained. The phase composition of the surface of the zirconia specimens was also analyzed using an X-ray diffractometer (Shimadzu XRD-6100; Shimadzu) with Cu K α X-rays over a 2θ angular range of 20–80° at an angular velocity of 5°/min. To evaluate the relative amount of phase transition, the monoclinic volume fraction was calculated in each specimen (Garvie and Nicholson, 1972). After surface treatment, all specimens in groups 1, 2, and 3 were divided into two sub-groups. Two different liners were applied to the treated surfaces of blocks in each pair of sub-groups: a) liner A (HZ groups: 1A, 2A, and 3A; Hotbond Zirconnect, DCM) and b) liner B (EZ groups: 1B, 2B, and 3B; IPS e.max Ceram ZirLiner, Ivoclar Vivadent). For the HZ groups, powdered liner A was mixed with carrier liquid (Hotbond carrier liquid) to a watery consistency. Each surface was sprayed with an airbrush and dried so that the thickness of surface coating, approximately 20 µm, could be achieved. The firing process was carried out according to the manufacturer's instructions to obtain a glassy surface. For the EZ groups, the creamy mixture of the powder of liner B and respective liquid (IPS e.max Ceram ZirLiner Build-Up Liquid allround) was layered on the zirconia surface. The layer thickness was approximately 0.1 mm after recommended firing. Subsequently, the powder and liquid components of a glass ceramic (IPS e.max Ceram, Ivoclar Vivadent) were mixed and applied to the prepared surface of each block. The layered ceramic was fired according to the manufacturer's recommendations and the veneering process was repeated to give a final thickness of 3 mm.

All the veneered zirconia blocks were sectioned into bars with dimensions of 3 mm × 3 mm × 13 mm for the shear bond strength test. A total of 126 zirconia specimens (six groups, $n=21$ per group) were embedded in the customized polytetrafluoroethylene molds. The specimens were then mounted in a jig and loaded into a universal testing machine (Model 3342, Instron). A shear force was applied directly to the core/veneer interface with a chisel-shaped piston at a crosshead speed of 0.5 mm/min until bond failure. The shear bond strength (MPa) was calculated by dividing the load at fracture (N) by the area of the bonded interface (mm^2). After the test, each specimen was ultrasonically cleaned. The fractured

Table 1 – Material properties according to manufacturers' data (CTE, Coefficient of thermal expansion).

Material	Manufacturer	Batch	Composition	CTE ($\times 10^{-6}/\text{K}$)
ZirBlank-PS	Acucera Inc., Korea	108081802	ZrO ₂ , Y ₂ O ₃ , HfO ₂	10.5
Hotbond Zirconnect	DCM, Rostock, Germany	130218	Unknown ^a	9.7
IPS e.max Ceram	Ivoclar Vivadent, Schaan, Liechtenstein	P11447	SiO ₂ , Al ₂ O ₃ , NaO, K ₂ O, ZnO, CaO, P ₂ O ₅ , F, other oxides	9.8
IPS e.max Ceram	Ivoclar Vivadent, Schaan, Liechtenstein	L43142	SiO ₂ , Al ₂ O ₃ , NaO, K ₂ O, CaO, P ₂ O ₅ , F, other oxides	9.5

^a The manufacturer did not provide authors with specific information of the material.

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