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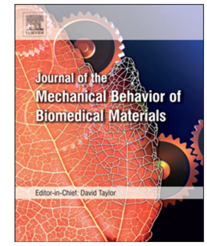

Research Paper

Evaluation of four surface coating treatments for resin to zirconia bonding

*Dan Liu, Edmond H.N. Pow, James Kit-Hon Tsoi, Jukka P. Matinlinna**

Dental Materials Science, Faculty of Dentistry, The University of Hong Kong, Hong Kong SAR, PR China

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ABSTRACT

Objectives: To compare the effects of four surface coating methods on resin to zirconia shear bond strength.

Material and methods: Eighty pre-sintered zirconia discs were prepared and randomly divided into five study groups according to the corresponding methods of surface treatments as follows: group C (control group, fully sintered without any surface treatment), group S (fully sintered and then sandblasted with silica coated alumina powder), group G (fully sintered and then coated with glazing porcelain followed by acid etching), group Si (pre-coated with silica slurry then fully sintered), and group Z (coated with zirconia particles and then fully sintered). The observation of surface morphology and elemental composition analysis were conducted by SEM and EDX. Self-adhesive resin cement stubs (diameter 3.6 mm and height 3 mm) were then bonded on the zirconia discs with a cylindrical shape. Both initial and artificial aged (including 30-day water storage, thermal cycling for 3000 and 6000 cycles) shear bond strengths were then evaluated.

Results: All the tested coating methods showed significantly higher shear bond strengths than the control group, in both dry and aged conditions. Group S produced the strongest initial zirconia/resin bonding (19.7 MPa) and the control group had the lowest value (8.8 MPa). However, after thermal cycling, group Z exhibited the highest mean value. All the samples in the control group failed in the thermal cycling. Both different coating methods ($p<0.001$) and various aging treatments ($p<0.001$) produced significant influence on resin–zirconia shear bond strength.

Conclusions: A reliable and durable resin zirconia bonding is vital for the longevity of dental restorations. Silica coating might be a reliable way in enhancing adhesion between resin and zirconia.

1. Introduction

Nowadays, the application of zirconia as a base material in the production of all-ceramic restorations has become one of the major foci in dental research. Such increase in the interest is ascribed to its high mechanical strength and exceptional biocompatibility (Liu et al., 2012; Manicone et al., 2007; Piconi and Maccauro, 1999). The success of zirconia-based all-ceramic

*Correspondence to: Dental Materials Science, Faculty of Dentistry, University of Hong Kong, 34 Hospital Road, Sai Ying Pun, Hong Kong, PR China. Tel.: +852 28590380; fax: +852 25489464.
E-mail address: jpmat@hku.hk (J.P. Matinlinna).

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restorations is highly dependent on the establishment of a strong adhesion between zirconia and luting cement. Compared with traditional luting cements, such as zinc phosphate, glass ionomer cement etc, resin cement has some irreplaceable advantages including higher mechanical strength and better esthetic properties (Piwowarczyk et al., 2005). However, without any surface treatment, the resin zirconia integration was found to be susceptible to aging conditions (Özcan et al., 2008). Meanwhile, the conventional bonding approaches, such as acid etching followed by the application of silane coupling agents, could not effectively improve the bond strength between zirconia copings and resin cement due to the chemical inertness of zirconia (Ho and Matinlinna, 2011a, 2011b). There is no inherent glass content in the matrix of zirconia abutment. Thus, zirconia base structures cannot be etched with commonly used mineral (or organic) acids, such as HF and H_3PO_4, for adding the surface roughness. Furthermore, it is also very cumbersome to form a strong chemical integration between zirconia coping and resin cement by using solely the conventional silane coupling agents (Kern and Wegner, 1998; Komine et al., 2012; Özcan and Vallittu, 2003).

Air-abrasion with alumina particles followed by an appropriate chemical bonding process was recommended to achieve long-term retention to zirconia (Kern, 2009). The incorporation of 10-methacryloxydecyldihydrogenphosphate (MDP) in primers or resin cements was a vital factor in producing durable resin zirconia bonding which has already been confirmed in the related clinical trials (Abou Tara et al., 2011; Sasse and Kern, 2013). Other surface treatments, such as the tribochemical method, selective infiltration etching, heating with a hot etching solution, laser surface treatment, plasma treatment and surface fluorination, have been developed for enhancing resin zirconia bonding (Heikkinen et al., 2009). Among these methods, sandblasting with silica coated alumina particles, combined with the application of MDP containing primer/resin cement has been recommended as one of the most effective methods (Atsu et al., 2006; Tanaka et al., 2008). This tribochemical method has been proven not only to increase the values of surface roughness, but also to add silicon (Si) content on zirconia surface. Silicon content is vital for activating the functions of silane coupling agents. Both mechanical interlocking and chemical integration between resin cement and zirconia have thus been enhanced (Peutzfeldt and Asmussen, 1988). However, there are still concerns about the influence of sandblasting on mechanical properties and long-term stability of zirconia base because sandblasting has been reported to induce some flaws on the surface (Zhang et al., 2004). The generation of such flaws might produce some detrimental effects on the reliability of zirconia substructures (Kosmač et al., 1999). For the other methods, some of them are time-consuming and not suitable for clinical application. Some protocols use very aggressive acids that may be detrimental to the health of operators. Further research has being performed for developing innovative approaches with more convenient and safe procedures.

Coating treatments on zirconia surface might also be regarded as one of the solutions to the current problems. For instance, it was reported that the application of a so-called glaze-on technique which is composed of the veneering of a thin layer of glazing porcelain on zirconia surface and the follow-on acid etching could result in the enhanced resin to zirconia shear bond strength. The addition of Si containing porcelain provided the necessary foundation for the establishment of chemical integration (Everson et al., 2011). Another study stated that the attachment of silicon dioxide (SiO_2) layer on zirconia surface with vapor-phase deposition method could provide functional sites for the use of silane coupling agents and improve resin zirconia adhesion subsequently (Piascik et al., 2009). Coating with zirconia particles also has helped to improve the resistance to the aging effects of water content at the zirconia/resin interface (Aboushelib, 2012; Aboushelib et al., 2009).

The aim of this study was to evaluate the differences between four direct zirconia surface coating methods and the effects on the shear bond strength between zirconia and resin cement. The hypothesis of the study was that the tested surface coating methods would produce the same effects on resin to zirconia bonding.

2. Materials and methods

2.1. *Preparation and grouping of pre-sintered zirconia specimens*

Eighty pre-sintered zirconia discs were cut from commercial dental zirconia ingots (Cercon base, DeguDent GmbH, Hanau, Germany) using a low speed diamond saw (Microslice, Metal Research limited company, England) under running water. Each disc was 25 mm in diameter and 1.5 mm in thickness. All the zirconia specimens were then polished with 1000-grit SiC abrasive paper on a polishing platform (Lumn Major, Struers, Denmark). They were randomly divided into five groups (C, S, G, Si, and Z) according to the corresponding methods of surface treatment:

Group C (control): the specimens in this group were densely sintered in a furnace (Cercon heat, DeguDent GmbH, Hanau, Germany) according to the manufacturer's instructions (maximum temperature of 1350 °C, and a sintering cycle of 6 h). They were not treated with any surface treatment.

Group S (sandblasting): in this group, the zirconia specimens were also densely sintered (using the same sintering program as group C) and followed by sandblasting. The process of sandblasting was carried out by an air-abrasion machine (Shofu Pen-Blaster, Shofu Dental Corporation, Kyoto, Japan) with 110-μm silica coated alumina powder (Rocatec®, 3M ESPE, Seefeld, Germany) at a constant pressure of 3.5 bar for 10 s. The working distance was 10 mm and directly perpendicular to zirconia surface.

Group G (glazing porcelain coating+acid etching): the slurry of glazing porcelain (Cercon Ceram Kiss Glaze, DeguDent, Germany) was prepared by mixing the glazing powders with corresponding modeling liquid. The zirconia specimens were fully sintered (using the same sintering program as group C) and then one thin layer of porcelain slurry was applied on the surfaces of each fully sintered zirconia with a clean brush and lightly vibrated. The specimens were then fired in a porcelain furnace according to the manufacturer's instructions. After being cooled to room temperature, each glazed zirconia surface was treated with an acid etching gel