DENTAL MATERIALS 32 (2016) 403–411

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.intl.elsevierhealth.com/journals/dema

Comparison of resin bonding improvements to zirconia between one-bottle universal adhesives and tribochemical silica coating, which is better?

Haifeng Xie[a], *Qiao Li*[b], *Feimin Zhang*[a], *Yi Lu*[c], *Franklin R. Tay*[d], *Mengke Qian*[a], *Chen Chen*[b,*]

[a] *Jiangsu Key Laboratory of Oral Diseases, Department of Prosthodontics, Affiliated Hospital of Stomatology, Nanjing Medical University, Nanjing, China*
[b] *Jiangsu Key Laboratory of Oral Diseases, Department of Endodontics, Affiliated Hospital of Stomatology, Nanjing Medical University, Nanjing, China*
[c] *School of Chemistry and Chemical Engineering, Nanjing University, Nanjing, China*
[d] *Department of Endodontics, College of Dental Medicine, Georgia Regents University, Augusta, GA, USA*

ARTICLE INFO

Article history:
Received 1 August 2015
Received in revised form
30 October 2015
Accepted 7 December 2015

Keywords:
Dental zirconia
Y-TZP
Bond
MDP
Adhesion
Primer
Universal adhesives
Phosphate ester

ABSTRACT

Objectives. To evaluate the bonding of resin-cement to yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) via silica coating followed by silanization, and three one-bottle universal adhesives, with or without prior conditioning using a zirconia primer.

Methods. Y-TZP specimens ($n = 160$) were conditioned by tribochemical silica coating and silanization (CS), or alumina sandblasting with one of the following MDP containing adhesives or primers: Z-Prime Plus™ (zirconia primer, ZP), Single Bond Universal™ (SU), Clearfil Universal Bond™ (CU) or All-Bond Universal™ (AU). Additionally, some specimens (ZPSU, ZPCU and ZPAU) received Z-Prime Plus™ followed by one of the three adhesives. After 24 h water storage and "aging" (20,000 thermocycles plus additional 40-day water storage), shear bond strength (SBS) was measured. Fourier-transform infrared spectroscopy (FTIR) and X-ray Photoelectron Spectroscopy (XPS) were employed for characterization of the chemical bonds between the primer/adhesives and the zirconia. Thermodynamic calculations were used to examine the hydrolytic stability between the MDP-zirconia chemical bonds and the SiO_2-silane chemical bonds.

Results. The CS and ZPCU groups showed higher SBS than the other six groups. There were no significant pairwise differences amongst ZP, SU and ZPSU, or amongst ZP, AU and ZPAU. Aging led to significantly decreased SBS for all groups except CS and ZPCU. There was no statistically significant interaction between surface treatment and aging. XPS determined the chemical bonds between MDP and zirconia. FTIR showed similar shifts in characteristic phosphate peaks for all the primer and/or adhesive groups. Result of thermodynamic calculation showed that equilibrium constant of SiO_2-silane system is much larger than the one of MDP-tetragonal phase zirconia system.

* *Correspondence to*: Han-Zhong Road 136th, Stomatological Hospital of Jiangsu Province, Nanjing 210029, China. Tel.: +86 25 8503 1822; fax: +86 25 8651 6414.
E-mail address: ccchicy@njmu.edu.cn (C. Chen).

http://dx.doi.org/10.1016/j.dental.2015.12.014

Significance. The application of one-bottle universal adhesives after alumina sandblasting is an alternative to tribochemical silica coating with silanization for bonding to zirconia, while bonding between resin and Y-TZP is more susceptible to hydrolysis when zirconia primer or one-bottle universal adhesive is used.

1. Introduction

Yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) ceramic has superior mechanical properties compared to other all-ceramic materials. Because of the intrinsic brittleness of Y-TZP and its tendency to undergo low temperature degradation, long-term survival of Y-TZP restorations still relies on adequate resin bonding [1,2]. After cementation, Y-TZP restoration-resin and cement-dentin combine tightly to form a "sandwich-like" structure consisting of two bonding interfaces. Both interfaces are important and methods have been developed to strengthen bonding at each of those interfaces. Bonding at the ceramic/resin interface is based on micro-mechanical interlocking and chemical bonding via primer conditioning [3–5]. Surface roughening alone was found to provide insufficient bond strength, although bond durability was improved [6,7]. Chemical bonding is more effective in increasing bond strength. Accordingly, surface roughening followed by acidic phosphate monomer conditioning (usually zirconia primers), and tribochemical silica coating followed by silanization, are the two most popular methods for Y-TZP bonding [8–11].

Although these aforementioned surface treatments work well on the Y-TZP/resin interface, they cannot be simultaneously used for improving resin/dentin bonding. Because surface treatments focusing on either dentin or Y-TZP usually employ many different products with different aims, it becomes necessary to adopt different operating procedures for each bonding substrate. This usually involves two, three or more steps, causing confusion to the clinician. Thus, there is a need to simplify such procedures to satisfy the clinical demand for faster, more consistent and less technique-sensitive methodologies.

Recently, one-bottle universal adhesives have been developed to bond with almost all indirect restoration materials, including resin composites, zirconia-based and alumina-based ceramics, silica-based glass ceramics, alloys, enamel and dentin. Manufacturers claim that components such as methacryloxydecyl dihydrogen phosphate (MDP) enable bonding to these surfaces without the use of primers. Amaral [6] and Seabra [12] found that application of one-bottle universal adhesives alone provided higher bonding strength to zirconia than application of zirconia primers alone. Nevertheless, literature on the influence of one-bottle universal adhesives on resin bonding to zirconia is rare [6,12]. In particular, there is no information on whether these adhesives provide stronger or more stable bonds when zirconia primers are used in advance. In addition, since tribochemical silica coating followed by silanization is still the most commonly used practice for pretreating Y-TZP bonding surface, it is more valuable to compare the bonding performance of one-bottle universal adhesives to zirconia with this gold standard, which will make the clinicians evaluate the new generation of adhesives more accurately. Thus, the objective of the present study was to evaluate the bonding of resin-cement to Y-TZP via silica coating followed by silanization, and three one-bottle universal adhesives, with or without prior conditioning using a zirconia primer. The null hypothesis tested was that pre-conditioning with a zirconia primer has no effect on improvement of bond strength and durability when one-bottle universal adhesives are used for bonding to zirconia.

2. Materials and methods

2.1. Bonding specimens

One hundred and sixty ceramic plates ($10 \times 10 \times 2\,mm^3$) were cut from a machinable Y-TZP block using a low-speed saw (Isomet 100, Buehler Ltd., Lake Bluff, IL, USA). Each plate was completely sintered according to the manufacturer's instructions. These Y-TZP plates were randomly assigned to eight groups) according to the conditioning method employed.

2.1.1. Group CS

Tribochemical silica coating was performed with 30 μm Cojet™ particles (3M ESPE, St. Paul, MN, USA) at a distance of 10 mm from the bonding surface for 15 s. Sandblasting was achieved using an intraoral sandblaster (Micro Etcher, Danville Materials, San Ramon, CA, USA) and an air pressure of 0.3 MPa. This was followed by the application of a silane coupling agent (Porcelain Primer, Bisco Inc.) to the sandblasted Y-TZP surface.

2.1.2. Group ZP

The bonding surface was sandblasted with 50 μm alumina particles from a distance of 10 mm for 20 s, at 0.3 MPa, using a sandblasting device (JNBP-2, Jianian Futong Medical Equipment Co., Ltd., Tianjin, China). A coat of Z-Prime Plus™ (Bisco Inc., Schaumburg, IL, USA) was applied to the sandblasted surface. After 15–20 s of volatilization, the primed Y-TZP surface was dried with low-pressure, oil-free air for 15 s.

2.1.3. Group SU

The Y-TZP surface was sandblasted with alumina as previously described. A coat of Single Bond Universal™ (3 M ESPE) was applied to the sandblasted surface and allowed to react for 15–20 s. The ceramic plate was air-dried to remove excess solvent. The adhesive was light-cured for 10 s.