



Fracture and shear bond strength analyses of different dental veneering ceramics to zirconia



Alexandre C. Diniz^a, Rubens M. Nascimento^b, Julio C.M. Souza^c, Bruno B. Henriques^{b,c}, Adriana F.P. Carreiro^{a,*}

^a School of Dentistry (DOD), Division of Prosthodontics, Universidade Federal do Rio Grande do Norte - UFRN, 59056-000, Natal, Brazil

^b Materials Engineering Department, Universidade Federal do Rio Grande do Norte - UFRN, Natal, Brazil

^c Centre for Mechanics and Materials Technologies - CT2M, Department of Mechanical Engineering (DEM), Universidade do Minho, Campus Azurém, 4800-058, Guimarães, Portugal

ARTICLE INFO

Article history:

Received 23 July 2013

Received in revised form 25 November 2013

Accepted 18 January 2014

Available online 24 January 2014

Keywords:

Dental porcelain

Zirconia

Shear test

Metal-free

Fracture

ABSTRACT

The purpose of this work was to evaluate the interaction of different layering porcelains with zirconia via shear bond strength test and microscopy. Four different groups of dental veneering porcelains (VM9, Zirkonanzh, Ceramco, IPS) were fused onto forty zirconia-based cylindrical substrates (8 mm in diameter and 12 mm in height) ($n = 10$), according to the manufacturer's recommendations. Additionally, layered dental porcelain (D-sign, Ivoclar) was fired on ten Ni–Cr cylindrical substrates. Shear bond strength tests of the veneering porcelain to zirconia or Ni–Cr were carried out at a crosshead speed of 0.5 mm/min. After the shear bond tests, the interfaces were analyzed by scanning electron microscopy (SEM). The fracture type exhibited by the different systems was also assessed. The results were statistically analyzed by ANOVA at a significant level of $p < .05$. The shear bond strength values of the porcelain-to-NiCr interfaces (25.3 ± 7.1 MPa) were significantly higher than those recorded for the following porcelain-to-zirconia systems: Zirkonanzh (18.8 ± 1 MPa), Ceramco (18.2 ± 4.7 MPa), and IPS (16 ± 4.5 MPa). However, no significant differences were found in the shear bond strength values between the porcelain-to-NiCr and porcelain (VM9)-to-zirconia (23.2 ± 5.1 MPa) groups ($p > .05$). All-ceramic interfaces revealed mixed failure type, cohesive in the porcelain and adhesive at the interface.

This study demonstrated that all-ceramic systems do not attain yet the same bond strength standards equivalent to metal–ceramic systems. Therefore, despite the esthetic appeal of all-ceramic restorations, the adhesion between the porcelain and zirconia framework is still an issue considering the long term success of the restoration.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

In oral rehabilitation, dental ceramics are useful for replacing dental crowns, providing esthetic characteristics that are similar to those of natural teeth [1–3]. This interesting application is mainly based on the optical properties and chemical stability of the ceramic materials [1–4]. A match of properties between the different material layers used to build a prosthetic crown improves the performance of that dental restorative system in the oral cavity. In fact, dental ceramics have undergone extensive study in recent years because of their attractive properties. Additionally, some improvements in their composition and properties have been reported in the literature [1–6].

Yttria-stabilized zirconia polycrystal (Y-TZP) has been applied since the 1990s in dentistry to synthesize frameworks of dental-fixed prostheses by slip-casting or CAD-CAM techniques. Y-TZP reveals a higher mechanical strength than that of feldspar-based porcelains or alumina

[7–11]. Such mechanical strength results from the phase transformation from a monoclinic to a tetragonal structure [9–11]. Previous studies have revealed flexural strength values for Y-TZP ranging from 900 up to 1200 MPa and a fracture toughness of 9–10 MPa·m^{1/2} [9–11]. Retrospective in vivo studies have revealed no fracture of Y-TZP frameworks over short [6] or medium [10,12] periods of evaluation. However, failures in dental porcelain-to-zirconia assemblies due to fractures along the porcelain-to-zirconia interface have been reported in previous studies [10–14]. Some findings have revealed failures at 8% of the dental porcelain-to-zirconia interfaces over a period of 36 months compared with 13% over 38 months [10–14]. Another study revealed failures at 15% of the dental porcelain-to-zirconia interfaces over a period of 24 months and 25% over 31 months [12]. However, a low failure rate (2.7–5.5%) has been revealed for metal-ceramic systems over periods of 10 and 15 years [15,16].

The clinical assessment of dental restorative systems is relevant to predicting the long-term performance of oral rehabilitation systems [17]. However, in vitro studies must be conducted to evaluate failures in the different situations that could occur from the processing of the structural material up to its use in the oral cavity. Thus, the chipping of veneering porcelains to frameworks can be associated with several

* Corresponding author at: Universidade Federal do Rio Grande do Norte, Departamento de Odontologia (DOD), Avenida Senador Salgado Filho, 1787, CEP: 59056-000, Natal, Brazil. Tel.: +55 84 3215-4135; fax: +55 84 3215-4104.

E-mail address: adrianadafonte@hotmail.com (A.F.P. Carreiro).

factors, such as: the veneering thickness and occlusal support [18]; the morphology of the circular finishing line [19]; adhesive forces between the framework and the veneering [4,20–37]; the mismatch of properties between the material layers [1,14,18]; the sensitivity of the technique used for porcelain application; and the residual stresses that are influenced by the cooling cycle during the veneering process [4,12,13,36–40]. Concerning ceramic materials, mechanical failures and the propagation of cracks through the dental porcelain when fused to metal or zirconia frameworks have been frequently reported in the literature [3,4,8–11,14,18]. There are a few *in vivo* studies that reveal details of the mechanical behavior of dental ceramics and other *in vitro* studies involving microscopic analysis of ceramic fractures [14,41].

The main aim of this work was to evaluate the shear bond strength of different layered dental porcelains to zirconia, followed by microscopic analysis of fracture surfaces, and to compare the shear bond strength of veneering porcelains to zirconia to that of veneering porcelain to metal. The null hypothesis of this study was that the shear bond strength values of veneering porcelains to zirconia and to metal were similar.

2. Materials and methods

2.1. Synthesis of specimens

Forty porcelain–zirconia specimens were synthesized by fusing 4 different dental feldspar-based porcelains (VM9, Zirkozanh, Ceramco, IPS) onto cylindrical zirconia substrates (frameworks). The structural materials used to synthesize the specimens are shown in Table 1. Cylindrical ceramic substrates (8 mm in diameter and 12 mm in height) were produced from yttria-stabilized tetragonal zirconia polycrystal (Zirkonzahn; Gais, Italy) by CAD-CAM method (Biodenta; Berneck, Switzerland). Porcelain-to-zirconia assemblies were divided into 4 groups ($n = 10$). However, dental veneering porcelain (D-sign, Ivoclar Vivadent; Schaan, Liechtenstein) was fused onto 10 cylindrical Ni–Cr substrates to synthesize ceramic-to-metal assemblies (control group). “The power analysis performed in order to determine the number of samples to be used in each group, indicated that using 10 specimens per group ($n = 10$) resulted in a power of 98%, which is higher than a power of 80%, usually considered to be sufficient power”.

For ceramic-to-metal systems, Ni–Cr cylindrical substrates (8 mm in diameter and 12 mm in height) were produced by the lost-wax casting method. After casting, the cylindrical substrates were finished by rubbing an alumina cone-shaped tool bit that was coupled to a high-speed rotating machine. The substrate area for porcelain application was grit-blasted by airborne-particle abrasion with alumina (Al_2O_3) particles (110 μm in diameter) under a pressure of 0.41 MPa for 15 s and at 10 mm from the surface. Before the application of the porcelain, the substrates were cleaned in propyl alcohol for 10 min and in distilled water for 1 min using an ultrasonic bath and were then dried at room temperature. A bonding porcelain (liner) was applied onto the zirconia substrates before the application of the veneering porcelain. The

veneering porcelain powder was mixed with distilled water at a 2:1 ratio to obtain a porcelain paste that was applied in layers (8 mm in diameter and 4 mm in height) onto the top of the surface area of the substrate using a stainless steel mold (Fig. 1A–B). The shrinkage of the porcelain occurring in the first firing cycle determined the application of a second porcelain layer on top of the first porcelain layer, followed by another firing cycle. The compaction and thermal treatment (firing cycle) of the veneering porcelains were in accordance with the manufacturer's recommendations (Table 2). The specimens are shown in Fig. 1C–D.

2.2. Shear bond tests and microscopic analysis of fracture areas

The cylindrical specimens were placed in a stainless steel apparatus for the shear bond tests (Fig. 1). The shear bond tests were performed at room temperature by applying a load on the ceramic area in line with the plane of the interface at a crosshead speed of 0.5 mm/min by using an Autograph Shimadzu AG-X 250 kN (Shimadzu; Japan). A stainless steel piston [34,36] was coupled to the shear test machine to load the specimen into the stainless steel jig. The shear bond strength (MPa) was obtained by the relation between the highest recorded fracture force (N) and the area of the adherent porcelain (mm^2). The results were statistically analyzed via one-way analysis of variance (ANOVA) with a significance level of $p < 0.05$ using the SPSS 17.0 software for Windows (Chicago, IL, USA). Tukey test was applied to compare the results between the groups.

After the shear bond tests, the fractured areas of the specimens were sputter-coated with a gold layer of 20 nm and inspected by scanning electron microscopy (XL-30 SEM; Philips) at 20 kV under secondary electrons (SE) mode. The failure pathways of the specimens were inspected.

3. Results

The shear bond strength values of the metal-free and ceramic-to-metal interfaces are shown in Table 3. Shear strength values recorded for veneering porcelains to zirconia substrate ranged from 16 up to 23 MPa (Table 3). No significant differences among three of the four ceramic-to-zirconia groups (CE, EM and IC groups) were found, as shown in Tables 3 and 4 ($p > .05$; power = 98%). The IC group revealed the lowest variability in the shear bond strength values, which might be related to greater homogeneity between the specimens of a group (Table 3).

The shear bond strength values of D-sign porcelain to Ni–Cr ($CG = 25.3 \pm 7.1$ MPa) were significantly higher than those recorded for the Ceramco (CE – 18.2 ± 4.7 MPa), IPS (EM – 16.2 ± 4.5 MPa) and Zirkonzahn (IC – 18.8 ± 1.0 MPa) groups. The Tukey multiple comparison test indicated no significant differences between porcelain-to-Ni–Cr (CG) and VM9 porcelain-to-zirconia (VM – 23.2 ± 3.8 MPa) groups.

After the shear bond test, the fracture surfaces were inspected by scanning electron microscopy (Fig. 2A). Those surfaces revealed

Table 1
Coefficient of thermal expansion and mechanical properties of the materials used in this study according to the manufacturer's instructions and previous studies.

Group	Material/manufacturer	CTE ^a ($\cdot 10^{-6} \cdot \text{K}^{-1}$)	Elastic modulus (GPa)	Fracture toughness ($\text{MPa} \cdot \text{m}^{1/2}$)
CE	Ceramco PFZ porcelain/Dentsply; USA	10.5	68 ± 2	0.9–1.2
IC	Zirkonzahn ICE porcelain/Zirkonzahn; Gais, Italy	9.6	65	0.8
VM	VM9 porcelain/Vita Zahnfabrik; Bad Säckingen, Germany	8.8–9.2	65	0.8
EM	IPS e.max ceram porcelain/Ivoclar-Vivadent; Schaan, Liechtenstein	9.8 ± 0.25	65 ± 10	0.7
CG	D-Sign porcelain/Ivoclar Vivadent; Schaan, Liechtenstein	12.6 ± 0.5	67	0.93 ± 0.1
C	Zirkonzahn/Y-ZTP/Zirkonzahn; Gais, Italy	10.5	210	9
M	NiCr alloy, Wironia Light/fBego; Bremen, Germany	13.8–14.1	200 ± 12	–

^a CTE – coefficient of linear thermal expansion.

Download English Version:

<https://daneshyari.com/en/article/1428818>

Download Persian Version:

<https://daneshyari.com/article/1428818>

[Daneshyari.com](https://daneshyari.com)