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Technical Note

Short communication Bond strength of a new generation of universal bonding systems to zirconia ceramic

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ABSTRACT

The purpose of this laboratory study was to evaluate the tensile bond strength of a new generation of universal bonding systems to zirconia ceramic and to compare the results with the bond strength of a clinically-established bonding system.

Eighty zirconia ceramic test specimens (e.max ZirCAD) were air-abraded and bonded to Plexiglas tubes, filled with an aliphatic dimethacrylate filling material (Clearfil F II), using three so called universal bonding systems of a new generation with different compositions (Monobond Plus/MultilinkAutomix, NX3, Scotchbond Universal/RelyX Ultimate). The latter was used also without the phosphate monomer containing primer Scotchbond Universal. A clinically established phosphate monomer containing adhesive cement served as control group (Panavia F2.0). The specimens were stored in water at 37 °C for 3 or 150 days and the long-term storage series were additionally thermal cycled between 5 and 55 °C for 37,500 times to simulate oral conditions. All specimens underwent tensile bond strength testing. The statistical analysis was performed using Kruskal-Wallis and Wilcoxon-Test with a Bonferroni-Holm correction for multiple testing.

After 150 days the median bond strength of RelyX Ultimate, with and without Scotchbond Universal, and Panavia F2.0 did not differ statistically (range: 21.7–28.8 MPa), while the bond strength of Monobond Plus/Multilink Automix was significantly lower (15.4 MPa), and that of NX3 the lowest (6.6 MPa). After 150 days of water storage with thermal cycling, all adhesive system showed significantly reduced tensile bond strengths compared to that after 3 days.

Only RelyX Ultimate was comparable to the established bonding system Panavia F2.0. The additional use of Scotchbond Universal did not result in a significant effect.

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1. Introduction

Ceramics are known to be an adequate material for different medical devices due to its adequate material properties and high biocompatibility (Manicone et al., 2007; Sentuerk et al., 2016; Chen et al., 2013; Baino FV-B, 2015). High-strength zirconia ceramics with high fracture resistance and optimized mechanical properties offer a wide range of clinical applications in dentistry as well, e.g. posts for endodontically treated teeth, implant abutments or cantilevered fixed dental prostheses. Various laboratory studies with many different methodologies have been conducted on bonding to oxide ceramics (Azimian et al., 2012; Inokoshi et al., 2013; de Souza et al., 2014; Lehmann and Kern, 2009; Papia et al., 2014; Özcan and Bernasconi, 2015). A recent systematic review summarized the bonding methods for oxide ceramics tested in laboratory studies and the authors identified 23 different surface treatment options that have been tested including, air-abrasion, tribochemical silica-coating or no treatment in combination with different primers or without primers (Papia et al., 2014). The huge variety of bonding methods and the great amount of laboratory research reveals the great interest in that research field.

Although conventional cementation with a glass ionomer cement of zirconia ceramic restorations is often possible, for many clinical applications, i.e. especially for non-retentive tooth preparations, reliable resin bonding to zirconia is desirable (Thompson et al., 2011). A recently published systematic literature review on bonding to oxide ceramics including laboratory testing and clinical outcome revealed strong clinical evidence that air-abrasion at a moderate pressure with Al_2O_3-particles in combination with a phosphate monomer containing primer or luting resin provides long-term durable bonding to high strength ceramics under clinical conditions (Kern, 2015). However, data on the long-term durability of bonding to zirconia ceramics using the new generation of so-called “universal bonding systems” are rare in the literature (Azimian et al., 2012; Attia and Kern, 2011). Bonding systems are very technic-sensitive in dentistry and a huge variety of different coupling agents for different dental materials as metal alloys, silicate ceramics or zirconia ceramics are available on the dental market. According to the manufacturer, so called “universal bonding systems” can be used for different dental materials and are able to bond to enamel as well as to dentine. Although it is already known from many different investigations how zirconia ceramic can be bonded successfully, it is essential for clinicians to learn whether the newly introduced “universal bonding systems” are applicable also for zirconia ceramic.

Therefore, the purpose of this laboratory study was to evaluate the bond strength to zirconia ceramic of three so-called universal bonding systems and to compare the results with the bond strength of a clinically-established phosphate monomer containing luting resin.

2. Materials and methods

The test method used a well-established test design, which had been described in detail previously (Kern and Wegner, 1998; Wegner and Kern, 2000).

2.1. Specimen preparation

Eighty disk-like specimens with a diameter of 6.4 mm and a thickness of 3.4 mm made from a densely sintered zirconia ceramic (e.max ZirCAD, Ivoclar Vivadent, Schaan, Liechtenstein) were provided by the manufacturer. All specimens were air-abraded with 50 μm Al_2O_3 and 0.25 MPa for 15 s and then ultrasonically cleaned with 99% isopropanol for 3 min (Elmasonic, S 30 H, Elma, Singen, Germany).

2.2. Bonding and aging

Acrylic glass tubes (inner diameter: 3.2 mm) filled with an aliphatic dimethacrylate filling material (Clearfil F II, Kuraray, Osaka, Japan) were bonded according to the manufacturers` recommendations to the pretreated ceramic specimens using one of the five adhesive systems presented in Table 1 ($N=16$). Composition and batch numbers of the materials are listed in Table 2. An alignment apparatus ensured that the tube axis was perpendicular to the bonding surface (Fig. 1). The excess was removed with foam pellets and an air blocking gel (Oxyguard, Kuraray, Osaka, Japan) was applied around the bonding margin to prevent an oxygen inhibition layer.

All specimens were light-polymerized from four sides for 15 s with a curing light (Elipar™ 2500, 3M Espe, Seefeld, Germany).

Each testing group was divided into two subgroups with eight specimen each, which were stored in water at 37 °C for 3 or 150 days to simulate intraoral conditions. The long-term storage subgroup was additionally thermal cycled between 5 and 55 °C with a dwell time of 30 s 37,500 times) (Kern and Wegner, 1998).

2.3. Tensile bond strength testing

Tensile bond strength (TBS) was measured using a universal testing machine (Zwick Z010/TN2A, Ulm, Germany) at a crosshead speed of 2 mm/min (Fig. 2). A self-alignment of the whole system and a moment-free axial force application was provided using an alignment jig, which was attached to the load cell and crosshead by upper and lower chains (Fig. 4). TBS was measured by dividing the force in Newton (N), which was needed to debond the specimen, by the bonding area in square millimeter (mm^2).

Table 1 – Bonding systems and group codes.

Group code	Bonding system
PAN	Panavia F2.0
MLA	Monobond Plus+Multilink Automix
NX3	NX3
RXU	RelyX Ultimate
S-RXU	Scotchbond Universal+RelyX Ultimate