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EVALUATION OF SHEAR BOND STRENGTH OF ADHESIVE RESIN CEMENT TO TWO CERAMIC MATERIALS

Toka Adel Rachid [1], Tarek Abd El Hamid [2], Mohamed Osama Atta [3]

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Glass ceramics, Zirconia, Surface Treatment, Shear bond strength.

- E-mail address: toka-adel@dent.suez.edu.eg

1. Demonstrator in fixed prosthodontics Department, Faculty of Dentistry, Suez Canal University
2. Lecturer of fixed prosthodontics, Faculty of Dentistry, Suez Canal University.
3. Professor of fixed prosthodontics, Faculty of Dentistry, Suez Canal University.

ABSTRACT

Introduction: The success of a ceramic restoration depends mainly on the nature, quality, and durability of the ceramic resin bond. **Aim:** This study aimed to compare the shear bond strength of two ceramic materials to adhesive resin cement. **Material & Methods:** Ten rectangular-shaped samples were cut from two ceramic materials (Zirconia reinforced lithium silicate (Celtra Duo) and monolithic translucent zirconia (Prettau Anterior)) using a low-speed cutting saw under copious water irrigation. Five large samples (12x14x3mm) and another five small samples (7x6x3mm). The large samples were embedded in epoxy resin blocks. Each ceramic material underwen t surface treatment according to the manufacturer's instructions. The bonded surfaces of Celtra Duo samples were etched with 9% hydrofluoric acid for 20 seconds and then Clearfill ceramic primer plus was applied. While the bonded surfaces of Prettau Anterior samples were sandblasted using 110 μm AL_2O_3 particles under 2.5 bar pressure for 15 seconds, then the Clearfill ceramic primer plus was applied. Finally, the large samples were bonded to their corresponding smaller samples of the same material using Panavia v5 cement. A Computerized universal testing machine was used to evaluate the shear bond strength. Each sample was firmly attached to the lower fixed compartment of the machine. A mono beveled chisel edge metal blade was attached to the underside of the upper movable compartment of the testing machine to apply compressive shear load parallel and as close as possible to the bonded interface at a cross head speed of 0.5 mm/min. **Results:** Results showed that the Celtra Duo samples had a statistically significantly higher shear bond strength to Panavia V5 adhesive cement (17.132±0.431MPa) than that of Prettau Anterior zirconia (14.046±0.488 MPa). Data were analyzed by independent sample t-test one at $p \leq 0.05$. **Conclusions:** The shear bond strength of the ceramic material bonded to resin cement was affected by the type of ceramic and surface treatment.

INTRODUCTION

The unique aspect of bonded ceramic restorations is the retention mechanism via the adhesive resin cement that intends to retain the restoration in place. So, evaluating the bond of the adhesive cement/ceramic substrate could be highly relevant for clinical success and longevity. Furthermore, the measurement of the shear bond strength of bonded restoration was advocated and considered to be very close to the nature of the intra-oral forces [1, 2].

A strong, durable resin bond provides high retention, improved marginal adaptation preventing microleakage, and increased fracture resistance of the restored tooth and restoration[3]. A strong resin bond to ceramic depends on micromechanical interlocking and chemical bonding. The micromechanical interlocking of the resin with the ceramic surface may be improved by surface roughening prior to cementation using either alumina sandblasting or hydrofluoric acid etching. While chemical bonding may be improved by the use of a resin cement containing MDP or a silane coupling agent.

Zirconia-reinforced lithium silicate glass ceramics as Celtra Duo is well documented to fulfill the highest esthetic requirements owing to the matrix being mostly glass. Furthermore, it is enriched with zirconia (≈10% by weight) to reinforce the material [4, 5]. Besides, it can be etched with hydrofluoric acid followed by silanization which could enhance the adhesion to resin cement.

Yttria partially stabilized zirconia (Y-TZP) is the most durable and has the best mechanical properties of all ceramic materials used in dentistry [6] . This material can nowadays be used in monolithic form with more conservative preparations and having high translucency owing to recent improvements in its optical characteristics [7, 8].

Prettau Anterior zirconia is newly introduced to dental market as a highly translucent zirconia with minimal abrasion of opposing dentition, and minimal tooth preparation requirements, which will all contribute to the increased longevity of such restorations[9].This recently introduced ceramic combines zirconia's usual mechanical resilience with outstanding translucency [10].

Limited studies have assessed the shear bond strength of these two types of ceramic materials to the adhesive resin cement. Therefore, the purpose of this study was to compare the shear bond strength of two different ceramic materials (Celtra Duo and Prettau Anterior) to Panavia V5 resin cement. It is hypothesized that Celtra Duo samples will yield shear bond strength values to resin cement higher than that of Prettau Anterior samples.

MATERIALS AND METHODS

I- Materials: The materials used in this study are listed in Table 1.

Table (1) *The materials used, Type, composition, and manufacturers.*

Materials brand name	Type	Composition	Manufacturer
Celtra Duo	Zirconia-reinforced lithium silicate	ZrO_2 10.1 % ,SiO_2 58.0 % ,Li_2O 18.5 % ,Other 13.4 %	Dentsply, Germany
Prettau Anterior	Translucent zirconia	ZrO_2 (92.27), $Y2O_3$ (5.2 mol %), Al_2O_3 (<1%), SiO_2 (0.02%), Fe_2O_3 (0.01%), and Na_2O (0.04%)	Zirkonzahn, Italy
Panavia v5	Adhesive resin cement	(Bis-GMA), (TEGDMA), hydrophobic aromatic dimethacrylate, hydrophilic aliphatic dimethacrylate, initiators, accelerators, silanated barium glass filler, silanated fluoroalminosilicate glass filler, colloidal silica, silanated aluminium oxide filler, dl-camphorquinone, pigments	Kuraray Noritake Dental, Japan
Hydrofluoric acid etch	Porcelain etch	Buffered 9% hydrofluoric acid	Ultradent, USA
Clearfill plus	Ceramic primer	10-MDP, Ethanol, 3-trimethoxysilylpropyl methacrylate	Kuraray Noritake Dental, Japan

II-Methods:

Ceramic samples preparation:

Celtra duo ceramic samples:

Five rectangular-shaped samples (14 × 12 × 3 mm) and another five smaller rectangular-shaped samples (7 × 6 × 3 mm) were cut from Celtra Duo CAD/CAM block (size C14) using a low-speed cutting saw (Micracut 125, Metkon, Turkey) under copious water irrigation. The Celtra Duo samples were cleaned in distilled water, grinding debris removed, dried and then glazed according to the manufacturer's instructions.

Prettau Anterior ceramic samples:

The Prettau Anterior zirconia samples were cut in larger dimensions to compensate for sintering shrinkage (18.5%). Five rectangular-shaped samples at initial dimensions (16.5 × 14 × 3.5 mm) were cut from Prettau Anterior CAD/CAM non-colored blank to be in final dimensions (14 × 12 × 3 mm) after sintering. Another five rectangular-shaped samples of smaller initial dimensions (8 × 7 mm × 3.5 mm) were also cut from the same CAD/CAM blank to be in final dimensions (7 × 6 × 3 mm) after sintering. The samples were cleaned in distilled water, grinding debris removed and dried. The Prettau Anterior samples were colored with Prettau Aquarell A2 coloring liquid (ZirkonzahnGmbH). The samples were then sintered in a high temperature furnace till reaching 1500 °C with a holding time of two hours. After which the samples were cooled down until reaching 500 °C then left to cool outside the furnace completely. Finally, the samples were glazed with Zirkonzahn glaze paste in accordance to the manufacturer's instructions.

The large dimension samples of Celtra Duo and fully sintered Prettau Anterior were embedded in self-cured acrylic resin blocks with only one side exposed so that the surface of the sample would be parallel to the edge of the resin blocks.

Surface treatment of the samples:

Celtra Duo:

All bonded surfaces of large and small Celtra Duo samples were etched with 9% hydrofluoric acid etchant gel (Porcelain etch, Ultradent, USA) for 20 seconds. The samples were then washed for 20 seconds and dried. Clearfill Ceramic primer plus was applied to Celtra Duo samples and then air-dried according to the manufacturer's instructions. The primer was applied on the bonding surface of the samples using a micro brush, agitated for 20 secs, and left to react for 40 secs. After that, the samples were gently dried with compressed air.

Prettau Anterior:

All bonded surfaces of large and small Prettau Anterior samples were air abraded in sandblasting unit using 110 μm AL_2O_3 particles under 2.5 bar pressure at a distance of 10 mm for 15 seconds. The samples were ultrasonically cleaned for 10 minutes to remove blasting particles, then air dried. Clearfill Ceramic primer plus was applied to sandblasted Prettau Anterior samples.

Bonding of the samples:

For each ceramic material, the small rectangular-shaped samples were bonded to their corresponding large rectangular samples which were embedded in acrylic resin blocks using universal shade of Panavia V5 adhesive resin cement according to the manufacturer's instructions. Equal amounts of paste A and B of cement were dispensed on paper pad and mixed for 20 seconds, applied to the treated surface of the small samples, then the small samples attached immediately to the middle of the large samples and a standardized load of 3 kg was applied using a specially designed loading device to ensure a uniform thickness of cement

The resin cement was light cured for 3 seconds per each side for initial setting and the excess cement was removed by using a probe. Light curing was then carried on for 20 second for each side of the samples

Shear bond strength testing:

The shear bond strength (SBS) of each specimen was done by using a computerized universal testing machine (TIRA test 2805, Schalkau, Germany). Each specimen was firmly attached to the lower fixed compartment of the machine. A mono-beveled chisel edge metal blade was attached to the underside of the upper movable compartment of the testing machine to apply compressive shear load parallel and as close as possible to the bonded interface at a cross-head speed of 0.5 mm/min (**Figure 1**).

Fig. (1) A photomicrograph showing Sample mounted on the universal testing machine for shear bond test using chisel edge blade.

In order to measure shear bond strength, the fracture load was recorded and then divided by the bonded surface area according to the following equation:

$$\text{Shear bond strength (Mpa)} = \frac{\text{Fracture load (N)}}{\text{Square bonded surface area (mm}^2\text{)}}$$

Bonded area of rectangular shaped samples (length×width) = 7×6=42 mm².

Statistical analysis

All data were collected, tabulated and statistically analyzed using the following statistical tests. A normality test (Kolmogorov-Smirnov) was done to check normal distribution of the samples. Descriptive statistics was calculated in the form of Mean ± Standard deviation (SD). Independent sample t-test was used to compare between two different tested groups in shear bond strength test The significance of the obtained results was judged at the 5% level (P-value ≤0.05).

RESULTS

Shear bond strength results:

Table 2 shows the mean shear bond strength values and standard deviation in MPa of Panavia v5 bonded to Prettau Anterior and Celtra Duo samples.

The results of this study showed that the Celtra Duo samples had a statistically significantly higher shear bond strength to Panavia V5 adhesive cement (17.132±0.431 MPa) than that of Prettau Anterior zirconia (14.046±0.488 MPa).

Table (2) *The mean shear bond strength values and standard deviation in MPa of Panavia v5 bonded to Prettau Anterior and Celtra Duo samples*

Material	Celtra Duo	Prettau Anterior	Test of significance
Mean± SD	17.132±0.431	14.046±0.488	T=14.023 P <0.001*

*T: Independent sample t-test *statistically significant (if p ≤ 0.05).*

DISCUSSION

Achievement of a durable bond between ceramics and resin cement is a primary requirement for successful restorations [11]. Therefore, this in vitro study aimed to compare shear bond strength of two different ceramic materials (Celtra Duo and Prettau Anterior) to adhesive resin cement.

Ceramic blocks for shear bond strength samples were manufactured in the form of rectangular shaped samples with two dimensions (14mm*12mm*3mm) and (7mm*6mm*3mm). This difference allowed the larger sample to act as a guide for the chisel tip to direct a parallel shearing force as close as possible to the ceramic/resin interface. Moreover, it allowed better control on bonding procedures and surface area since the bonding area is confined to the area of the small bonded sample.

The Celtra Duo samples recorded higher mean SBS values than Prettau Anterior samples with a statistically significant difference. Therefore, the hypothesis that Celtra Duo samples will yield bond strength values higher than Prettau anterior was accepted. The higher shear bond strength results of Celtra Duo samples to resin cement might be attributed to the fact that the etched lithium silicate produced higher surface roughness than that produced by alumina sandblasted zirconia. The increased roughness is supposed to provide more surface area for bonding which could directly contribute to increasing shear bond strength results [12, 13].

Moreover, the depth of penetration of micro pores created by hydrofluoric acid etching seems to be deeper than that produced by alumina sandblasting which might have provided more depth of interlocking of the resin tags into the ceramic which might explain the higher shear bond strength results of Celtra Duo samples to resin cement than that of Prettau Anterior samples [14, 15] .

Ramakrishnaiah et al (2016)[16] reported that the increased surface roughness had a direct effect on increasing the wettability of the ceramic surface by resin cement. Based on this scientific fact it could be said that more resin cement could be penetrated into the etched ceramic (Celtra Duo) surface and held responsible for creating higher shear bond strength results to adhesive resin cement.

Furthermore, the high shear bond strength between Celtra Duo samples and Panavia v5 cement may be due to the increased chemical adhesion of resin cement to Celtra Duo samples. This may be attributed to the advantage of the application of clearfill ceramic primer containing silane to etched Celta Duo samples. Silane is responsible for the high affinity of the adhesive cement to Celtra Duo samples as it is a bifunctional molecule that acts as a strong bonding agent to create the adhesion between two dissimilar materials. It contains two different, reactive functional groups: one end reacting with methacrylates to copolymerize with the organic matrix of the resin and the other reactive toward the remaining silica in ceramics [17]. Moreover, usage of silane combined with MDP (10-methaacryloxy decyl dihydrogen phosphate) further improves the bond strength of resin cement to Celtra Duo samples owing to bonding of MDP molecules to the 10% ground zirconia present in the matrix of Celtra Duo ceramic[18].

On the other hand, silane had no effect on the shear bond strength of Prettau Anterior zirconia to Panavia V5 cement due to absence of silica in the polycrystalline matrix of zirconia with its chemical adhesion relying mainly on chemical reaction between oxide content and adhesive MDP molecules in the applied ceramic primer. MDP is a functional group with a long organic hydrophobic chain molecule with two ends. One end has vinyl groups that react with the monomers of the resin cement when polymerized and the other end, hydrophilic phosphate ester groups bond strongly with oxide content [19]. Chemical reactions involving the hydroxyl groups of zirconium oxide and the phosphate ester monomers of the MDP may occur only at the interfacial level [20, 21].

Based on the above-mentioned scientific reports, the higher shear bond strength results of Celtra Duo samples/Panavia V5 cement over Prettau Anterior samples/ Panavia V5 cement could be justified.

The results of this study came in agreement with Wille et al (2017) [22] who reported higher mean shear bond strength values of etched lithium disilicate than alumina abraded zirconia samples.

CONCLUSION

Within the limitations and conditions of this in vitro study, it was concluded that Celtra Duo ceramic showed higher shear bond strength values to Panavia v5 cement than Prettau Anterior ceramic.

Suggestions for further studies

It would be beneficial to support these findings with clinical studies.

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