14th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2010, Mediterranean Cruise, 11-18 September 2010

SHEAR BOND STRENGTH OF DENTAL SELF – ADHESIVE RESIN CEMENTS

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ABSTRACT
The continuous technological advance and increasing availability of new dental self adhesive resin cement in the market, coupled to the demands of daily clinical practice, have made the determine mechanical properties. This study evaluated the shear bond strength of ceramics cemented by three different dental self-adhesive resin cements. Shear bond strength was measured with an Instron servo hydraulic testing machine by applying parallel shear forces to the specimens until fracture. Special tools were made for testing cylinder specimens (10 mm high; 3 mm diameter). In the paper, we explain the testing, measuring and calculative techniques.
The results showed that etching with 4.9% HF acid is most effective for Variolink II cement (31.19±8.66), whereas sandblasting with Al2O3 particles of IPS e.max ceramic specimens obtained results in favour of Relyx Unicem (35.14±5.91) and Panavia F (25.56±5.21) cements.
Keywords: shear bond strength, dental self-adhesive resin cements, FEM analysis

1. INTRODUCTION
The increased interest in ceramic restoration, with no metal, is significant during last few years. The patient demands nowadays, such as high esthetic criteria stands before stomatologist and led to the development of the new ceramic materials in stomatology in addition to development of the new adhesive systems. The recommended way of fixing ceramic restoration lies in the use of adhesive systems namely, composite cements. The bond between ceramic materials and composite cements

represents very important aspect in a process of cementing ceramic restoration from the scientific as well as from the clinical point of view.
Creating a bond of ceramic materials and resin-based cements is a specific and complex clinical procedure in the process of cementing ceramic restoration. When bonding ceramic restorations to the teeth structure, it is necessary to take into account the two interfaces: dentin/cement and cement/ceramic. The achieved optimal bond strength is responsible to the overall quality of the both interface adhesion, as one of the main factors in evaluating the ceramic structure benefits.
Various of studies have reported that resin-based luting agents improve the retention and efficacy of indirect ceramic restorations. [1,2]
Adhesion between dental ceramics and resin-based cements is a result of physicochemical interactions of the adhesive and ceramics surface. A number of preparation techniques of ceramic cores which improves the strength of cement-ceramic adhesion are described and examined in the literature. Current techniques are: (1) grinding, (2) abrasion with diamond rotary instruments, (3) surface abrasion with alumina particles, (4) acid-etching (typically hydrofluoric acid [HF]), and (5) a combination of these techniques. [5]

2. EXPERIMENTAL METHODOLOGY AND TECHNIQUE

Two groups of ceramic speciments were used for this study.
First, with a total of 172 cylinder-shaped samples (3mm in diameter and 10 mm length) were fabricated from zirconium-based Y-TZP ceramic discs (Zeno Tec System, Wienland, Germany). The samples were cleaned for five minutes in an ultrasonic bath containing distilled water, air dried, then divided into three test groups for each surface pretreatment: Group 1 (HF): etching with 4,9 % hydrofluoric acid (IPS Ceramic etching gel; Ivoclar Vivadent, Liechtenstein) applied for 20 seconds, water cleaned for 20 sec., and air dried for 30 sec.; Group 2 (SC): tribochemical silica coating with 50 µm Al_2O_3 particles modified by silica oxide (3M ESPE, Seefeld, Germany), group 3 (NT): no surface treated. For each surface preparation group the specimens were randomly divided into four additional groups.
Second group consisted of 240 lithia-disilicate ceramic cylinders (IPS e.max Press; Ivoclar-Vivadent, Shaan, Liechtenstein) were fabricated according to manufacturer's instructions. Ceramic specimens were cleaned for five minutes in an ultrasonic bath containing distilled water, air dried, divided in two equal experimental group and surface treated with 4.9% HF and sandblasted with Al_2O_3 particles.
For cementation, of all ceramic speciments, were used two groups of composite cements, 4 commercial products. Each of resin cements ware applied to the surface of prepared group of ceramic specimens according to the manufacturers' instructions, at room temperature (23.0±1.0 °C) and relative humidity (50%±5%).
Ceramic to ceramic luting procedure was performed using digital caliper, specially modified for this experiment. In order to achieve optimal thickness, the samples were draw to each other until the value of 40 µm cement interlayer is obtained. After checking the thickness once more, the excessive cement was dismantled using metal spatula, identically for all samples. While using Panavia F 2.0 cement, Oxygard 2.0 was applied to the exposed margins to minimize oxygen inhibition. 40 seconds of light irradiation (Optilux 501, Kerr UK: 940 mmW/cm^2) from each side of specimens were performed in order to ensure the optimal polymerization. The bonded specimens were stored in a laboratory in dark container, until the shear bond strength test was performed.

2.1. Shear bond strength test and Finite Element Modeling

The shear bond strength were measured with a universal servo-hydraulic testing machine INSTRON - 1332, Fig. 1a, retrofited by FastTrack 8800 Compact Digital Control Electronics of a 5 kN load cell operating at a crosshead speed 0.5 mm/min. During the testing procedure, the 0,5 mm stainless steel plate was positioned between the handler and the specially designed "knife" in order to achive loading at the exact point for all samples, not to the cement layer, than at the begining of ceramic. The shear load at failure was recorded in N and calculate to MPa as a function of the specimen area under test loading [6].
A schematic of the present 3D numerical FE model is shown in Fig.1b. The model was created and solved using the ANSYS 5.7 FE package using 10-node tetrahedral structural solid elements (an option of 20-node solid brick elements). Typical representative FE grid, shown in Fig. 2a, contained 168,111 elements and 240,596 nodes. Each node had three degrees of freedom corresponding to the three degrees of translation.

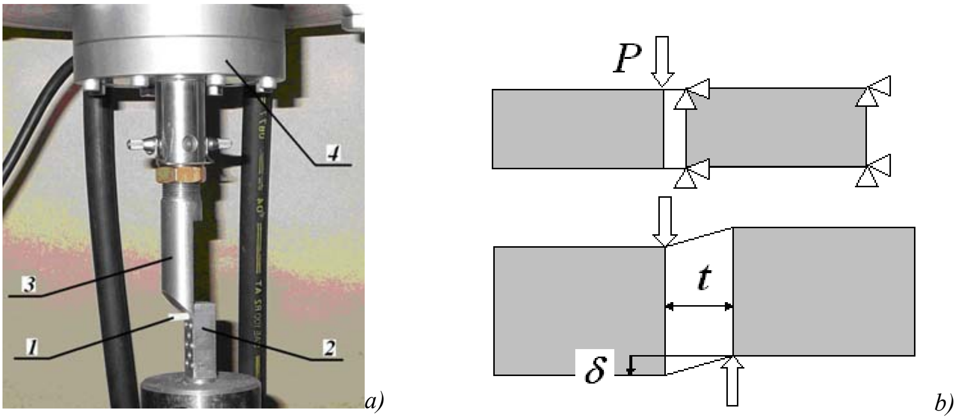

Figure 1. a) Statement of the shear bond strength test (1) specimen, (2) fixsing leg, (3) shera "knife", (4) load cell Instron 5kN; b) schematic of FE model with applied boundary conditions

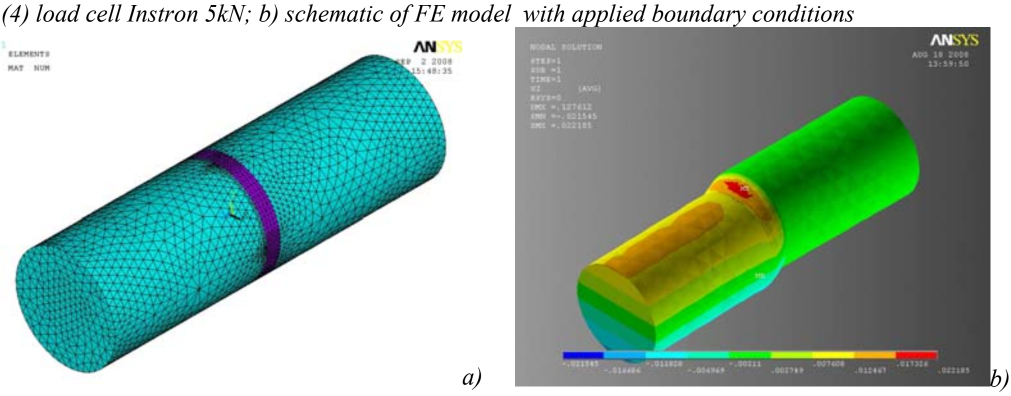

Figure 2. a) Typical representative FE grid of model with contact region and b) Contour plots of deformation in z direction

A finer mesh is used in the contact region. This model has been analyzed by the selection of a suitable FE mesh to model each material phase and by the prescription of appropriate boundary conditions.

The model is considered by introducing boundary conditions, Fig 2.(a), which force shearing in contact region – 0.4mm thick bond cement.

The average shear stress generated in that section is simply : $\tau = 4P/d^2\pi$, where P is applied load and d is specimen diameter. Moreover shear modulus G can be easily calculated from: $G = \tau/\gamma$, where $\gamma=\delta/t$ is shear strain which is proportional to displacement δ. Values for P and δ are obtained from load displacement curve for each considered specimen combination.

The model is loaded in the vertical (y) direction with adequate isplacement steps. After loading, due to the applied loads and the boundary conditions, in contact region not only shearing but also bending will occur as shown on Fig. 2b.

Detailed FE analysis confirmed that observed bending, when compared with shearing, is neligible sugesting that shearing is dominant over bending. This imply that proposed experimental shear test method, even not standard method such as for example the rail shear test, is valid to obtain shear properties of considered dental materials.

All materials are modeled as isotropic, elastic solids using the classical linear elasticity model. This model assumes that: (a) elastic properties for ceramic and cement phases are linear; (b) the ceramic and cement phases are isotropic; (c) the ceramic and cement phases will not fail at the prescribed loads that are lower than failure load, and (d) the interfaces between each constituent are assumed to be perfect bonds, such that decohesion does not occur between the materials in contact region.

3. RESULTS AND DISCUSSION

The mean shear bond strengths (SBSs) of Y-TZP are displayed in Fig. 3. Generally, the results of multiple ANOVA showed that all four resin cements exhibited significantly higher SBSs when specimens were surface treated with Co-Jet. Multiple Turkey HSD comparation of average results SBSs for Maxcem and Variolink 2 resin cements showed that there were no statistically differences, whereas Relyx exhibited significantly lower ($p<0,0001$) and Panavia F higher results ($p<0,026$) when surface treated with HF acid. Average results of SBS of Variolink 2 resin cement was lower then at the other resin cements but without significant statisticall difference, confirmed with Independent Samples Test.

The mean shear bond strengths (SBSs) of IPS e.max Press are displayed in Fig. 4. The results showed that etching with 4.9% HF acid is most effective for Variolink II cement (31.19±8.66), whereas sandblasting with Al2O3 particles of IPS e.max ceramic specimens obtained results in favour of Relyx Unicem (35.14±5.91) and Panavia F (25.56±5.21) cements [7].

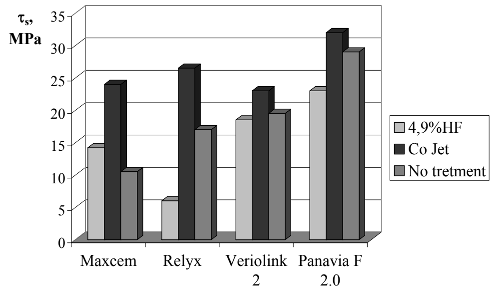

Figure 3. The shear bond strengths of each resin cement with different surface treatment

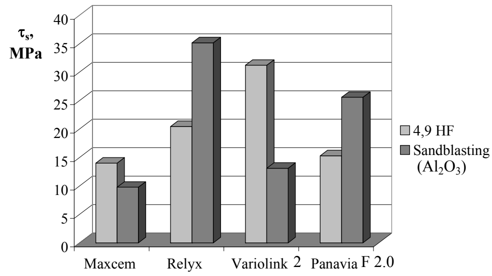

Figure 4. The shear bond strengths of each resin cement with different surface treatment

4. CONCLUSION

The excellent agreement between experimental results with FEM results is a proof that the projected methodology of investigation is well selected.

The bonding strength between ceramic materials and composite cements depends on the way of preparing the ceramic base.

Ceramic materials of the high density such as yttrium stabilized zirconium dioxide can not be successfully prepared by the abrasion with HF acid in order to ensure the bonding of the ceramic materials to composite cements.

With zirconium dioxide ceramic materials, for the purpose of providing stabile chemical bonding to composite cements, the efficient way of preparation is the treatment with silane layer deposited by special equipment.

ACKNOWLEDGMENTS

The authors acknowledge gratefully Serbian Ministry of Science and Technological Development for funding this work under the project numbers 19047 TR.

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