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Residual stress estimates from crack branching in incompatible zirconia/veneer discs

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Veneer cracking on zirconia core dental material is presenting as a clinical concern. There is no standard method for calculating the magnitude of residual stress that causes these crack patterns.

Objective: Determine the thermal incompatibility stresses (σ_R) for veneers on zirconia specimens, using the previously established relationship between failure stress and crack branching coefficients (CBC).

Materials and methods: Discs (12 mm dia) were fabricated using nano-composite Ce-TZP/ Al_2O_3 cores, liner and veneer (Matsushita Elec Works Ltd., Japan). The ceramic core/veneer thicknesses were: 0.6_c/0.6_v; 0.4_c/0.8_v; 0.8_c/0.4_v. Specimens were placed on an epoxy substrate (3.6 mm) and stored in DI water at 37 °C for ~1 year. After aging, multiple cracks in specimens were identified visually. Delaminated veneer-from-core specimens were examined under SEM; crack origins identified; and the failure stress calculated ($\sigma_R = K_{IC}/[(Y)(c)^{0.5}]$). The non-delaminated cracked veneers underwent fiber optic illumination, microscopic examination, image capture and stress analysis using a grid dimension technique. The number of cracked veneer segments per specimen was recorded. A log/log graph of box counts (N) in 8 sizes (L), and grid areas (L_{max}) was used to establish the crack branching coefficient: $CBC = \log[N(L)]/\log[L_{max}/L]$ (Sakai, 1991; Mecholsky, 1998). The CBC was related to the calculated σ_R of like-specimens.

Results: The internal σ_R values calculated from fracture origins of the veneer/core delaminated specimens for 0.4_c/0.8_v and 0.6_c/0.6_v were 40 and 61 MPa, with 3 and 7 veneer segments, respectively, and CBCs of 0.54 ($R^2 = 0.97$) and 0.65 ($R^2 = 0.99$), respectively. Mean CBCs were: 0.56 for 0.6_c/0.6_v and 0.60 for 0.8_c/0.4_v. Based on the CBC values, the highest internal failure stress was in the thinnest veneer (0.8_c/0.4_v), with less veneer internal failure stress in the 1:1 ratio (0.6_c/0.6_v).

Conclusions: The residual stresses (CBC) tended to increase with an increase in veneer/core thickness ratio. The indication is that further investigation with a larger sampling will demonstrate that this technique compliments other methods for thermal incompatibility residual stress estimation in bilayer dental ceramic systems.

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Effects of recasting titanium for ceramo-metal dental prostheses on the mechanical properties, microstructure and fracture mode

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Objectives: This study evaluated the effect of the Ti condition (as-received and re-cast) on the mechanical properties, microstructure and fractography.

Materials and methods: Castings ($n=6$) with Ti in the as-received and once recast condition were made in a centrifugal casting machine using a high-purity argon gas. The ultimate tensile strength (UTS), proportional limit (PL) and elongation (EL) of the as-received specimens were evaluated in a universal testing machine at a crosshead speed of 1 mm/min. The fractured specimens were polished down for Vicker's microhardness (VHN) measurement (100 g/15 s) from 25 μ m below the cast surface, then at 50, 100, 200 and 500 μ m. The microstructures of the alloys were also revealed. Scanning electron microscopy fractography (SEM) was undertaken for the fractured surfaces after testing. The data from the mechanical tests and hardness were subjected to Student t-test and a two-way repeated measures ANOVA, respectively. Tukey's test was used for pairwise comparison ($\alpha=0.05$).

Results: Higher UTS, PL and VHN and lower EL were observed for recast cp Ti. The microstructure was not influenced by the Ti condition and the SEM shows several transverse cracks on as-received cp Ti castings, on the other hand, fewer cracks can be observed in the outer surface of re-cast cp Ti.

Conclusions: Despite the likely increased contamination when cp Ti is a 100% re-casted, this does not seem to cause any detrimental changes in the mechanical properties of the cp Ti. Therefore, the re-cast of casting surplus can be another alternative to reduce the costs involved in the Ti castings.

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Adhesive durability of phosphate monomer resin cement to Y-TZP ceramic

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Objectives: We have recently reported [1] the processing and physico-chemical characterization of a yttria-tetragonal zirconia polycrystal (Y-TZP) ceramic produced via coprecipitation with mechanical properties comparable to commercially reinforced ceramic materials. The purpose of the present investigation was to study the bond durability between

the experimental zirconia and a phosphate monomer resin cement after two surface conditioning methods. The hypothesis tested was that bond strength is influenced by both the surface conditioning methods and storage conditions.

Materials and methods: Y-TZP ceramic powders stabilized with 3 mol% of yttria were pressed and sintered at 1500 °C. Polished ceramic blocks (6 mm × 5 mm × 5 mm) were randomly assigned into 3 groups according to surface conditioning: SC-1: (Al₂O₃) airborne-particle abrasion + silanization, SC-2: (SiO_x) tribochemical silica coating + silanization and SC-3 (control): no surface treatment. Resin cement containing phosphate monomer¹ was used as adhesive cement. After 24 h storage in distilled water (37 °C), the specimens were reduced to bonding areas of approximately 0.6 mm². The 3 groups of specimens were subdivided and microtensile testing (1 mm min⁻¹) was performed in the as-processed condition (dry) and after storage for 150 days and thermocycling (12000×, 5–55 °C). Tensile stress to failure was analyzed at 95% level of significance. Failure mode was assessed using scanning electron microscopy (SEM).

Results: Both the surface treatment ($p < 0.01$) and the storage conditions ($p < 0.01$) affected the results significantly (Two-way ANOVA, Tukey's). Interaction terms were not significant ($p = 0.232$). The highest percentage of pretest failures were experienced in the non-conditioned group (dry: 9%, aged: 87%). Bond strength values obtained for the tribochemical silica coating conditioning method (17.6 ± 4.4 MPa) were only slightly higher yet statistically significant than those obtained with airborne-particle abrasion (Al₂O₃) (15.1 ± 6.9 MPa) and control (12.4 ± 5.0 MPa). Long-term water storage and thermocycling however reduced the bond strength values significantly ($p < 0.001$). Overall the mean bond strength values obtained from long-term water stored and thermocycled conditions (1.5–4.0 MPa) were significantly lower than those of the dry (immediately tested) groups (12.4 ± 5.0–17.6 ± 4.4 MPa). SEM evaluation showed that all the fractures were mixed in all experimental groups.

Conclusions: Panavia F did not deliver acceptable bond strengths when the tested zirconia surfaces were not conditioned. Hence, even though in dry conditions favorable results were obtained with both particle abrasion methods, after aging, the results were poor.

¹Panavia F, Kuraray Co, Japan.

REFERENCE

[1] Lazar, et al. Dent Mater 2008;24:1676.

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Table 1

Self adhesive cements	Time 0	6 months
Voco self-adhesive	7.8 ± 2.9 ^a	6.7 ± 0.8 ^a
RelyX Unicem	8.4 ± 3.7 ^a	6.7 ± 2.6 ^a
MaxCem	4.6 ± 1.8 ^b	1.6 ± 0.6 ^c

Different superscript letters indicate statistical difference ($p < 0.05$).

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Bond strength of posts luted with different self-adhesive resin cements

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Objectives: Self-adhesive cements represent a new approach in fiber post-cementation. Aim of this study was to investigate the effect of storage in artificial saliva on bond strength of fiber posts luted with three different self-adhesive cements.

Materials and methods: Human incisor roots were prepared as follows: (1) experimental Voco self-adhesive with Rebuilda-posts (VO, Voco), (2) RelyX Unicem with RelyX Unicem-posts (RX, 3M ESPE) and (3) MaxCem with Rebuilda-posts (MC, Kerr). Bonded specimens were sectioned in 1 mm-thick slabs and either submitted to storage in artificial saliva in incubator at 37 °C for 6 months or retrieved as controls prior to be submitted to push-out bond strength testing.

Results: A significant bond reduction was recorded after storage only for MaxCem. Mean values (MPa) and standard deviations are shown in Table 1.

Conclusions: MaxCem revealed the lowest bond strength both at time 0 and after 6 months of storage. No difference was found between Voco Self-Adhesive Cement and RelyX Unicem and both cements were not affected by storage.

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Strength degradation of dental ceramics after in vitro aging

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Objectives: To evaluate the strength degradation of five ceramics (yttria stabilized zirconia, YZ; alumina polycrystal, AL; glass-infiltrated alumina-zirconia, ICZ; and porcelains VM7 and VM9, all from Vita) after *in vitro* aging procedures. The null hypothesis is that these procedures cause strength degradation in all ceramics.

Materials and methods: For YZ, AL and ICZ, ceramic bar-shaped specimens were obtained by sectioning commercial blocks. Porcelain specimens were produced by sintering. Spec-