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Cements Adhesion to Ceramic as a Function of Surface Treatment

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Rationale:

Bonding to ceramic surfaces is in great interest in dentistry. However, some ceramics, like zirconia, are known as very inert to the most conventional methods used in their preparation. Commercially available priming materials that contain silane coupling agents are reported as significantly enhancing bonding abilities of adhesive resin cements to zirconia and other ceramics.

Objectives:

To evaluate shear bond strength (SBS) of the adhesive resin cements to ceramic surfaces as a function of different surface preparation methods.

Introduction:

Establishing a strong bond between all-ceramic restorations and the tooth structure is a prerequisite for a successful restoration, as it will increase fracture resistance of the restoration, prevent microleackage, and enhance the retention and stability of the restoration. However, establishing a strong and durable bond to zirconia has been quite a challenge in the dental field due to the chemical inertmess of the material, and without a proper surface treatment or application of suitable priming agent, the shear bond strength between zirconia and luting cement was reported to be only about 1.5 MPa [1].

Approaches such as micromechanical retention, chemical bonding, or a combination of both have been described as prerequisites for achieving a reliable bond between resin cements and zirconia restorations.
Silane coupling agents (silanes) are well-known hybrid inorganic-organic compounds to form covalent chemical bond between dissimilar materials that is glassy ceramics (oxides) and organo-functional monomers [2-3]. Recently appeared commercially available priming materials that contains Methacryloyl-dexyl-methacrylate (MDP) or silane coupling agents are reported as significantly enhance bonding forces of adhesive resin cements to ZrO_2 and other ceramics [1, 4].

Materials and Methods:

SBS testing of the commercially available adhesive resin cements was conducted to various ceramic blocks utilizing different preparation methods and materials according to ISO/TS11405:2003. All data was statistically analyzed by the analysis of variance (ANOVA) method, at a significance level set at $p < 0.005$.

Materials:

Adhesive Resin Cements:

- High-Q-Bond (HQB), B.J.M. Laboratories Ltd.
- High-Q-Bond SE (HQBSE), B.J.M. Laboratories Ltd.
- MaxCem, Kerr

Surface Preparation Materials:

- Porcelain Fix comprising Etch and Silane, B.J.M. Laboratories Ltd.
- Q-Ceram Ceramic Primer, B.J.M. Laboratories Ltd.

Ceramic Blocks:

- IPS e.max *Lithium disilicate (LS_2) glass-ceramic*, Ivoclar Vivadent
- IPS Empress-Multi *Leucite-reinforced glass-ceramic*, Ivoclar Vivadent
- ZirCom-Zirkonblank *zirconium oxide (ZrO_2)*, ComProDent
- Vitablocs for CEREC / InLab, Mark II 2M2C I14, VITA
- Lava-Ultimate CAD/CAM Restorative, A3-LT for CEREC, 3M ESPE

Methods:

- Flat bonding sites were prepared on the flat surface of 8 ceramic specimens.
- Prior to bonding surface was rinsed with acetone and dried.
- Tested cement was applied on the surface in accordance with the instruction for use.
- Cylinders of composite were bonded to bonding site, using:
  - Gelatin capsule technique in which a resin cylinder 3.5 mm in diameter were prepared in the following manner: transparent gelatin capsules, half filled with cured hybrid composite, 3.5 mm in diameter, were bonded to the bonding site. Uncured cement was syringed to fill the other half of the gelatin cap and placed on the bonding site. The gelatin was light cured for 20 seconds from 2 opposite directions. The specimens were stored in distilled water at 37ºC for 24 hours.
- The specimens were placed in a Lloyd Testing Machine (Model LR 10K, Lloyd Instruments, Serial No. 9211) equipped with a load cell of 500 N and a chisel-shaped rod (Bencor Multi-T Testing Device) to deliver a shearing force.
  The specimens were aligned with the shearing rod against and parallel to the bonding site.
- Each bonded cylinder was placed under continuous loading at 1.0±0.1 mm per minute until fracture occurs.
- Shear bond strengths were calculated in megapascals (units MPa). The fracture sites will also be examined to determine the failure mode.

Results:

Following tables summarize the above SBS (MPa) test results.

Materials and Methods	Vivadent E.max	Vivadent Empress-Multi	ComProDent ZirCom-Zirkonblank	VITA Vitablocs	3M ESPE Lava-Ultimate
Sandblasted[1] ceramic surface					
HQBSE	15.7±2.1	12.8±2.4	16.3±3.2	2.1±0.2	11.4±3.6
Porcelain Etch -> Porcelain Silane -> HQBSE	25.5±2.5	24.3±3.9	18.2±7.4	12.3±2.1	N/A
Q-Ceram -> HQBSE	25.9±1.3	27.5±1.9	29.3±2.8	9.8±5.3	14.9±2.8

[1] Sandblasting is not applicable for Vitablocks and Lava-Ultimate Blocks.

Materials and Methods	Vivadent E.max	ComProDent ZirCom-Zirkonblank
No sandblasting applied to a ceramic surface		
MaxCem	6.4±2.1	5.4±2.9
Q-Ceram -> MaxCem	27.4±9.1	18.5±7.6
HQB	8.9±2.0	3.0±0.9
Porcelain Etch -> Porcelain Silane -> HQB	19.5±3.4	9.8±1.2
Q-Ceram -> HQB	24.1±1.9	18.7±2.8

Conclusions:

Tested cements demonstrated good adhesion to ceramic surfaces treated with Porcelain Etch followed by Silane and with Q-CERAM as well. Q-Ceram is preferable for zirconia treatment. The above primer – cement combinations can be recommended for bonding procedures while adhering dental cement to the above surface.
Bond durability should be tested in order to understand potential of the long-term use of the above adhesive joints.

It has become more obvious that the bonding interface is a very complex region where different materials meet. At this interface, chemical and micromechanical retention, surface roughness and porosity, chemical composition, polymerization stresses, water absorption, and cyclic loading interact all together. The end result is the long-term performance of the bond under the influence of fatigue and biodegradation.

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