Bond Strength of Different Self-Adhesive Cements to Different Metal and Ceramic Substrates

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Purpose

The purpose of this study was to evaluate the bond strength of a newly developed resin cement (Maxcem Elite) to different substrates and comparing the results to other commercially available self-adhesive cements. The present part of the study focused on the bond strength on various metal and ceramic substrates before and after application of surface treatments.

Methods and Materials

Fabrication of metal and ceramic substrates samples

The following materials were used as substrates in this study:

- Partially stabilized zirconia blocks
- Sintered feldspatic porcelain Vitablocks
- Lucite glass ceramic IPS e-max CAD blocks
- High noble gold alloy Type II blocks
- Ni-Cr base-metal alloy blocks

Ten flat pieces of each material were embedded in acrylic resin exposing one of the surfaces. The exposed surface was ground with 320 grit silicon carbide sanding paper until a flat surface was achieved. Afterwards, surfaces were finished with 600 grit silicon carbide sanding paper.

Surface treatments

Zirconia, gold and base metal surfaces were tested in two different ways: a) polished with 600 grit sandpaper and b) air particle abraded with 50 μm alumina. Vitablocks and e-max CAD-blocks were also tested two different ways: a) polished with a 600 grit sandpaper and b) etched using IPS ceramic etching gel (Ivoclar-Vivadent, USA) and silanized using Monobond-S (Ivoclar-Vivadent, USA).

Tested cements

The following cements were tested for shear bond strength on the above mentioned surfaces before and after the surface treatments:

- Maxcem Elite
- Maxcem
- RelyX Unicem Cliker
- G-Cem
- FujiCem Automix

Bonding and testing

Cements were applied following manufacturer's recommendations for each substrate. Substrates specimens were held by bonding jigs (Ultradent Inc.) with a cylindrical mold (2.38 mm diameter). The mold was then filled with the corresponding cement. The whole bonding assembly was conditioned at 37°C and 100% humidity for at least one hour before the bonding jig was removed. Specimens were stored at 37°C and 100% humidity for 24 hours, at which time they were tested.

Shear bond strength was measured using a Dillon Quantrol testing machine at a test speed of 1mm/min. A notched crosshead designed to match the diameter of the bonded specimen was used to apply the testing load. The specimens were placed in a test base clamp, which was free to move to facilitate positioning under the load. The test base was then positioned so that the notched crosshead was placed against the artificial substrate surface and the notch is fitted on the diameter of the bonded composite specimen. The load required to debond the specimen was recorded and the mean bond strength of the ten specimens calculated by dividing the load by the surface area of the bonded specimen and expressed in MPa.

Data entry, tabulation and analysis

The shear bond strength values were analyzed by using one-way analysis of variance (ANOVA) to evaluate if there was any difference between the tested materials. If differences were found, a Newman-Keuls test was applied to identify those differences. All the statistical test were performed at 95% confidence level.

Results

Differences between cements

Figure 1 shows mean values of shear bond strength obtained for each cement on not treated surfaces.

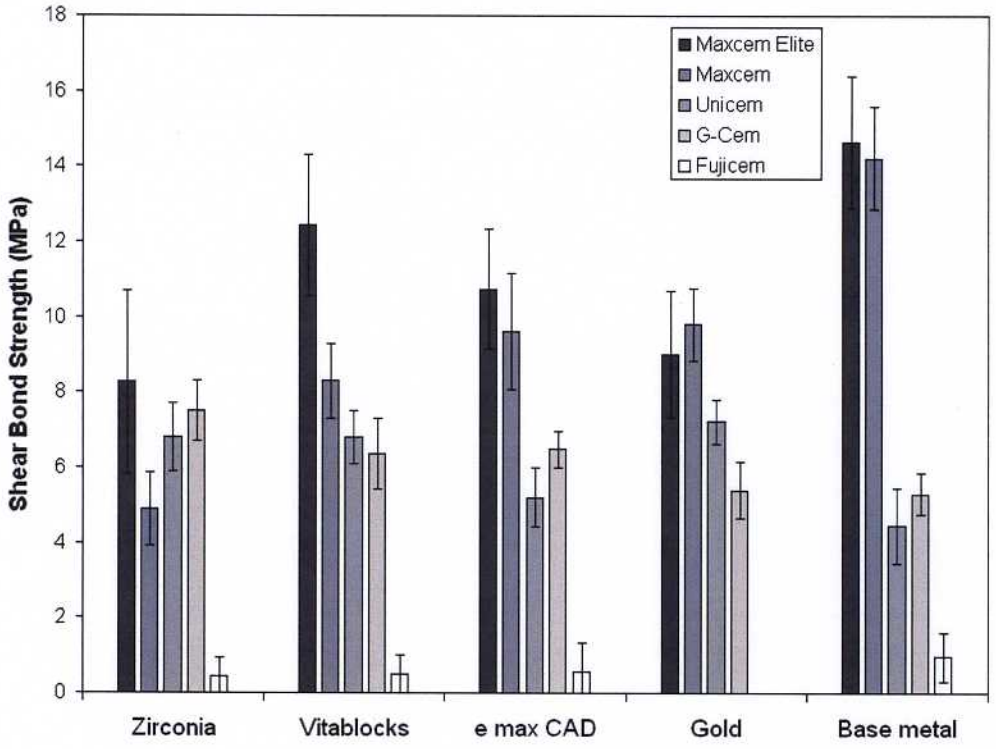

Figure 1. Mean shear bond strength values on not treated surfaces

When applied without any surface treatment, Maxcem Elite showed the highest mean values of shear bond strength for all the tested surfaces except for gold. On this surface, the highest mean value was obtained with Maxcem. On the other hand, Fujicem showed very poor adhesion on all the tested artificial substrates. Most of the samples prepared with this cement broke when they were removed from the molds or when they were placed on the jig for testing. ANOVA and Newman-Keuls test results for each surface are summarized in Table 1

As shown in Figure 2, after surface treatment of the substrates higher values of shear bond strength were obtained for all the cements.

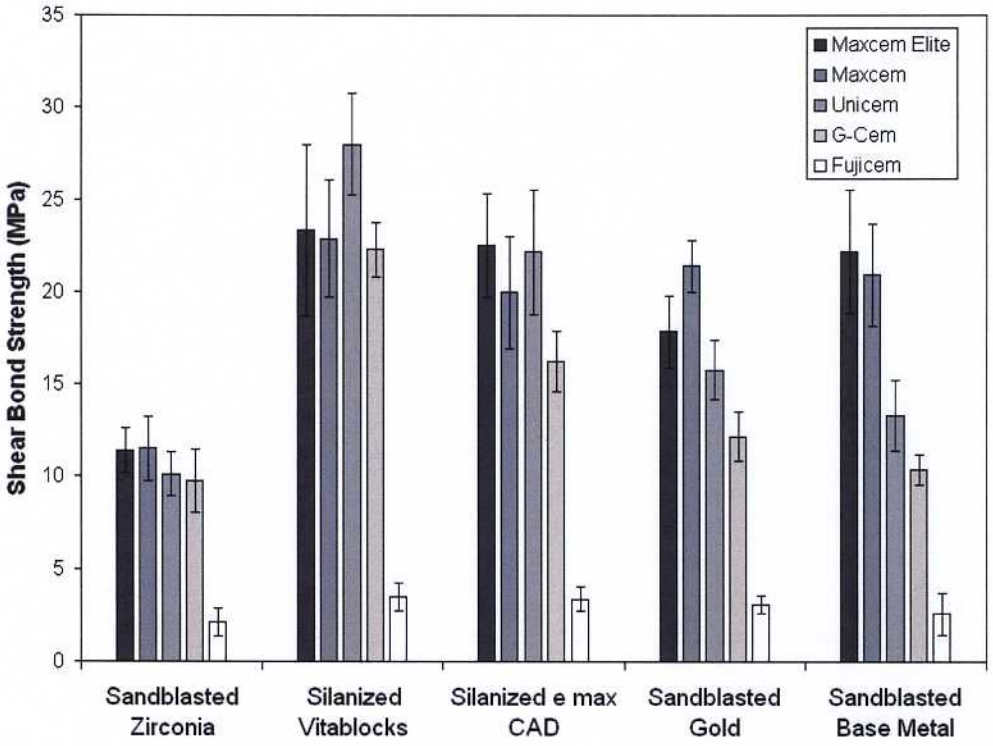

Figure 2. Mean shear bond strength values on treated surfaces

On sandblasted zirconia, Maxcem showed the highest bond strength. On silanized Vitablocks, the highest value was obtained with Unicem and on silanized e.max CAD blocks, Maxcem Elite showed the highest adhesion. When gold and base metal were treated with air particle abrasion and bonded to Maxcem Elite and Maxcem, they produced the highest bond strength among all the cements tested. For all the tested surfaces, Fujicem showed significant lower values than the other four cements. For both sandblasted zirconia and sandblasted base metal, five (50%) of the samples of Fujicem broke before a detectable force was applied. Those samples were not considered for the calculations. One-way ANOVA revealed statistically significant differences between shear bond strength of the different cements for all the tested surfaces. Table 1 summarizes mean values and results of Newman-Keuls test for each cement.

Table 1. Shear bond strength mean and standard deviation values. . For each surface and treatment, superscripts on values with the same letter specify groups of not statistically different values

	Not treated surfaces				
	Gold	Base metal	Zirconia	Vitablocks	e.max CAD blocks
Maxcem Elite	9.0 (2.8)^{a}	14.6 (2.9)^{a}	8.3 (4.1)^{a}	12.4 (3.2)^{a}	10.7 (2.7)^{a}
Maxcem	9.8 (1.6)^{a}	14.2 (2.3)^{a}	4.9 (1.6)^{b}	8.3 (1.7)^{b}	9.6 (2.6)^{a}
Unicem	7.2 (1.0)^{b}	4.5 (1.7)^{b}	6.8 (1.5)^{a,b}	6.8 (1.2)^{b}	5.2 (1.3)^{c}
G-Cem	5.4 (1.2)^{c}	5.3 (0.9)^{b}	7.5 (1.4)^{a}	6.4 (1.6)^{b}	6.5 (0.8)^{c}
Fujicem	0 (0)^{d}	1.0 (1.1)^{c}	0.4 (0.8)^{c}	0.5 (0.8)^{c}	0.5 (1.3)^{d}
	Treated surfaces				
	Sandblasted Gold	Sandblasted Base metal	Sandblasted Zirconia	Silanized Vitablocks	Silanized e.max CAD blocks
Maxcem Elite	17.8 (3.3)^{b}	22.2 (5.7)^{a}	11.4 (2.0)^{a}	23.4 (7.5)^{a}	22.5 (4.5)^{a}
Maxcem	21.4 (2.4)^{a}	20.9 (4.7)^{a}	11.5 (2.8)^{a}	22.9 (5.1)^{a}	20.0 (4.9)^{a,b}
Unicem	15.8 (2.7)^{b}	13.3 (3.3)^{b}	10.1 (1.9)^{a}	28.0 (4.4)^{a}	22.2 (5.5)^{a}
G-Cem	12.2 (2.3)^{c}	10.3 (1.3)^{b}	9.8 (2.7)^{a}	22.3 (2.4)^{a}	16.2 (2.7)^{b}
Fujicem	3.1 (0.8)^{d}	2.6 (1.5)^{c}	2.1 (0.8)^{b}	3.5 (1.2)^{b}	3.6 (1.0)^{c}

Differences between substrates

All the tested cements showed the highest bond strength values when they were tested on silanized Vitablocks. Table 2 summarizes ANOVA and Newman-Keuls test results for bond strength values on treated and not treated substrates. Significant differences in shear bond strength between sandblasted and not sandblasted zirconia could not be detected for Maxcem Elite (P=0.655) and Unicem (P=0.070). For all other tested groups, significant differences were detected on shear bond strength before and after surface treatment.

Table 2. Shear bond strength mean and standard deviation values. SB: sandblasted, SI: silanized . For each cement, superscripts with the same letter specify groups of not statistically different values

	Maxcem Elite	Maxcem	Unicem	G-Cem	Fujicem
SB-Gold	17.8 (3.3)^{b}	21.4 (4.7)^{a}	15.8 (2.7)^{c}	12.2 (2.3)^{c}	3.1 (0.8)^{a}
Gold	9.0 (2.8)^{d}	9.8 (1.6)^{c}	7.2 (1.0)^{d,e}	5.4 (1.2)^{f}	0 (0)^{b}
SB-Base Metal	22.2 (5.7)^{a}	20.9 (4.7)^{a}	13.3 (3.3)^{c}	10.3 (1.3)^{d}	2.6 (1.5)^{a}
Base Metal	14.6 (2.9)^{b,c}	14.2 (2.3)^{b}	4.5 (1.7)^{e}	5.3 (1.0)^{f}	1.0 (1.1)^{b}
SB-zirconia	11.4 (2.1)^{c,d}	11.5 (3.0)^{b,c}	10.1 (2.0)^{d}	9.8 (2.9)^{e}	2.1 (1.0)^{a}
Zirconia	8.3 (4.1)^{d}	4.9 (1.6)^{d}	6.8 (1.5)^{d,e}	7.5 (1.4)^{f}	0.4 (0.8)^{b}
SI-Vitablocks	23.4 (7.9)^{a}	22.9 (5.4)^{a}	28.0 (4.7)^{a}	22.3 (2.5)^{a}	3.5 (1.2)^{a}
Vitablocks	12.4 (3.2)^{c,d}	8.3 (1.7)^{c}	6.8 (1.2)^{d,e}	6.4 (1.6)^{f}	0.5 (0.8)^{b}
SI-Pro-CAD blocks	22.5 (4.7)^{a}	20.0 (5.1)^{a}	22.2 (5.8)^{b}	16.2 (2.8)^{b}	3.4 (1.0)^{a}
Pro-CAD blocks	10.7 (2.7)^{c,d}	9.6 (2.6)^{c}	5.2 (1.3)^{e}	6.5 (0.8)^{f}	0.5 (1.3)^{b}

Summary:

In summary both Maxcem Elite and Maxcem had excellent bond strengths with and without surface treatment of the different substrates.

Carlos Munoz, DDS, MSD — Date: 05-22-08

Marc Campillo, PhD — Date: 05-22-08