Dentin Bond Strength of NX3 Resin Cement

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INTRODUCTION

Dual-cure resin cement has been the material of choice for cementing various indirect restorations because it possesses many desirable properties such as excellent mechanical strength, high fracture toughness, choice of curing mechanisms, and most importantly esthetic properties (good translucency). However, most dual-cure resin cements use BPO (benzoyl peroxide)/tertiary amine pair as their redox initiator system and suffers two serious drawbacks as a result: (1) significant long-term discoloration, making them unsuitable for cementing esthetic porcelain/ceramic restorations; and (2) bond incompatibility with more acidic single-bottle adhesives such as the 5th & 7th generation adhesives.

The bond incompatibility between resin cement and more acidic single-bottle adhesive is encountered when cementing metal-based or rather opaque restorations where there is limited or no light accessibility and the cement has to be self-cured. This bond incompatibility could be attributed to the inability of the BPO/Amine redox initiator system used in current resin cements to initiate polymerization in the dark and in the presence of quite acidic monomers within the air-inhibited layer of light-cured adhesives as a result of an acid-based reaction. To minimize this incompatibility problem, some manufacturers provided a separate Activator that needs to be mixed with the single-bottle adhesive for enhanced dark-cure efficiency. Although effective, the activator introduces complexity into the bonding process in that there is an additional component and an extra mixing step involved.

Recently, a new dual-cure resin cement NX3 was introduced that employs a novel amine-free redox initiator system for improved bond compatibility and long-term color stability. NX3 can be used with both total-etch and self-etch adhesives. It also simplifies cementation procedures by eliminating the self-cured activator for the single-bottle adhesive so that no mixing is required for the adhesive regardless of whether it is a total-etch or self-etch adhesive.

OBJECTIVE

To test and compare the dentin shear bond strength (SBS) of NX3 in combination with either a total-etch adhesive OptiBond Solo Plus (Kerr) or a self-etch adhesive OptiBond All-In-One (Kerr) without an activator, along with several commercial resin cements in combination with their respective primers/adhesives/activator.

MATERIALS

NX3/OptiBond Solo Plus (without activator)	Kerr
NX3/OptiBond All-In-One (without activator)	Kerr
Calibra/Prime&Bond NT (with Activator)	Denstply
Multilink/(Primers A + B)	Ivoclar
Nexus 2/OptiBond Solo Plus (with Activator)	Kerr
Panavia F2.0/(ED Primers A + B)	Kuraray
RelyX ARC/Single Bond	3M ESPE
Variolink II/Excite DSC (with Activated brush)	Ivoclar

METHODS

Extracted human teeth were embedded in cold-cure acrylics. A set of six specimens were prepared for each group. A low speed diamond saw was used to remove the crown and expose the occlusal dentin. The dentin substrates were polished with 240-grit and then 600-grit SiC paper. If a total-etch adhesive is used, then the dentin substrates were etched with 37% H_3PO_4 gel etchant (Kerr) for 15 seconds, rinsed thoroughly with water, and air dried for a few seconds. Each adhesive (or mixed adhesive/activator if an activator is recommended) was then applied to the dentin surface according to the manufacturer's instructions, air dried, and light-cured if indicated. The adhesive covered substrate was then held securely by a bonding jig (Ultradent Inc.) with a cylindrical mold (Φ = 2.38 mm). The mold was then filled with each adhesive's respective cement, and the cement was self-cured. The whole bonding assembly was conditioned at 37ºC in a high humidity chamber (85-90% relative humidity) to allow the cement to self-cure for one hour before the bonding jig was removed. The prepared specimens were then stored in de-ionized water at 37ºC for 24 hours before being subjected to debonding under shear force.

The specimens in each group were tested on an Instron mechanical tester (Model 4467, Instron Corporation) in shear mode using a notched (semi-circular) edge at a crosshead speed of 1.0 mm/min. Shear bond strength values in MPa were calculated by dividing the peak load by the bonding area.

Statistical analysis was performed using One-way ANOVA and Bonferroni's method for pair-wise comparison to determine significant differences among groups ($p<0.05$).

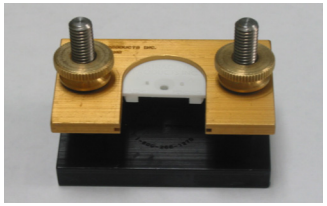


Figure 1: *Bonding Jig*

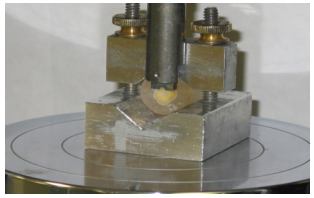


Figure 2: *Shear Bond Test Set-Up*

DISCUSSION

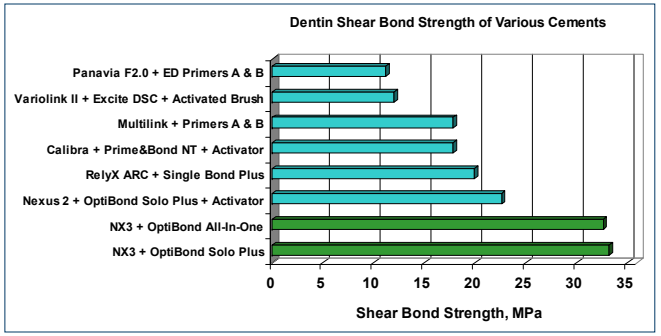
The relative ranks of SBS for all cements in combination with their respective adhesives are as follow: NX3 (w/ OptiBond Solo Plus) ≥ NX3 (w/ OptiBond All-In-One) > Nexus 2 ≥ RelyX ARC ≥ Calibra ≥ Multilink ≥ Variolink ≥ Panavia F2.0

ANOVA analysis revealed that, the dentin SBSs of NX3/OptiBond Solo Plus and NX3/OptiBond All-In-One are not statistically ($P>0.05$) different from each other, but both are significantly ($p<0.05$) higher than those of all other cements. This clearly demonstrates NX3's superior bond compatibility with both total-etch and self-etch adhesives. This enhanced bond compatibility for NX3 could be attributed to its proprietary amine-free redox system that is quite resistant to acidic monomers within the air-inhibited layer of the light-cured adhesive. What is even more noteworthy is the fact that the enhanced bond compatibility of NX3 with both total-etch and self-etch adhesives is achieved without using an activator for the adhesives. As a direct comparison, using the same OptiBond Solo Plus adhesive system, NX3 (omitting the Activator for the adhesive) yielded significantly ($p<0.05$) higher dentin SBS than Nexus 2 (using the Activator for the adhesive). Without the need for an activator, NX3 resin cement offers a much simplified cementation procedure with less component and less step (no mixing is required for the adhesive). The mixing of an adhesive with an activator is required for most other cements included in this study. For some cements, severe bond incompatibility is encountered if the activator for the adhesive is omitted. As an example, when the activator was omitted for Calibra/Prime&Bond NT system, a dentin SBS of 0 MPa (i.e. automatic debonding) was obtained, versus 17.8 MPa when the activator was used.

RESULTS

Cement (self-cured)	Adhesive/Primer System	Dentin SBS, MPa
NX3	OptiBond Solo Plus	33.2±3.2[a*]
NX3	OptiBond All-In-One	32.6±5.5[a]
Nexus 2	OptiBond Solo Plus+Activator	22.6±1.3[b]
RelyX ARC	Single Bond Plus	19.9±1.8[b]
Calibra	Prime&Bond NT+Activator	17.8±2.1[b,c]
Multilink	Primers A+B	17.8±5.3[b,c]
Variolink	Excite DSC(+Activated brush)	12.0±6.6[c]
Panavia F2.0	ED Primers A+B	11.2±1.9[c]

*Means with different letters are statistically different at $p < 0.05$.



CONCLUSIONS

NX3 dual-cure resin cement exhibited excellent bond compatibility with both total-etch and self-etch adhesives, and produced the highest dentin SBS among all cements/adhesive systems in this study. The superior bond compatibility between NX3 and adhesive is achieved even without the need for an activator, resulting in a much simplified cementation procedure as no mixing is needed for the adhesive. NX3's enhanced compatibility with both total-etch and self-etch single-bottle adhesive could be attributed to its proprietary amine-free redox initiator system.