FINAL REPORT

Comparative Evaluation of Bond Strengths of Panavia and Primabond 97 to Posts Cemented into Root Dentin

by

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INTRODUCTION

Previous tests of the strengths of bonds between materials and dentin have utilized flat surfaces. Relatively large (ca. 3-4 mm diameter) cylinders of resin composite were bonded to these flat surfaces and, 24 hrs. later, the bond strength was usually tested in shear. When the resin bonds were relatively weak (5-15 MPa), the bonds usually failed adhesively and the force at failure divided by the bonded surface area gave a good measure of the material's bond strength. However, as resin adhesives were improved, the strength of adhesion to dentin increased to 20-30 MPa (Pashley et al., 1995). When tested in shear, as many as 60% of the specimens failed in dentin. That is, the actual bond between resin and dentin did not fail because of cohesive failure of dentin. This led some to suggest that the cohesive strength of dentin was between 20-30 MPa, which is incorrect. Even deep dentin has a strength of about 45 MPa (Smith and Cooper, 1971). The dentin failed cohesively due to high stress concentrations which develop locally in bonded specimens due to nonuniform stress application (Van Noordt *et al.*, 1989; 1991; Versluis *et al.*, 1997).

Clinically, one rarely sees dentin fail cohesively. Thus, improvements were required in the manner in which bonded specimens were tested. Sano *et al.* (1994) developed what has been called a microtensile testing method. In that study, the authors divided bonded test specimens into vertical slabs about 0.5-1 mm thick. They trimmed the specimens into hour-glass shapes to improve stress distributions and to insure that all of the stress was focused on the smallest cross-sectional area. As they reduced that cross-sectional area, the apparent bond strength increased dramatically. More importantly, fewer specimens exhibited cohesive failure in dentin and more specimens failed adhesively. At cross-sectional areas of $\leq$ 1.0 mm, almost all failures were adhesive. That is, the values that were measured could be unambiguously interpreted as indicating interfacial adhesive bond strength.

A similar problem exists in attempts to measure the strength of bonds between cements and endodontic posts. Tensile tests in which the post is pulled from the canal often cause fractures of the root that do not mimic clinical experience. Due to the small size and curved nature of root canals, it is not possible to measure resin-dentin bond strength using conventional techniques because there are no flat surfaces.

The purpose of this study was to adopt the microtensile bond testing method to permit measurement of bond strengths between resin cements and endodontic posts and to compare the bond strength of Primabond 97 with Panavia 21.

MATERIALS and METHODS

Teeth

Twenty-four human extracted cuspid teeth, stored in isotonic saline containing 0.2% sodium azide, were used in this study. The purpose of this study was to measure μTBS between preformed posts and dentin roots and to compare the bond strengths of Primabond Resin Cement with Panavia 21.

Preparing Post Space

The crowns of the teeth were removed at the cementoenamel junction (CEJ) by means of an Isomet saw (Figs. 1A, 1B). The root canals were prepared and incrementally enlarged with IntegraDrills (yellow) to an appropriate diameter and depth (Figs. 1C, 1D) then rinsed with water and a micro-brush (HAWE Endobrush), (Fig. 1E). An IntegraPost that corresponded to the last drill size used was then selected (#6). The labial portion of the root was sanded away with #320 silicon carbide paper, under running water, to expose the prepared canal parallel to the long axis of the tooth (Figs. 2A, 2B). The posts were fitted to the (labial opened root canal) (Fig. 2C). The posts were sandblasted (MicroEtcher, Danville Engineering, Danville, CA) with 50 micron alumina particles at an air pressure of 50 PSI and washed with a water spray. All prepared posts were kept dry and contamination-free. The posts were cemented in canals with either Primebond 97 or Panavia 21 resin cements, with and without primer, according to the manufacturer's instructions (Fig. 2C). That is, resin cement was applied to the posts and into the canals and then the posts were seated. The cemented specimens were placed in 100% humidity for 1 hr, then in water for 24 hrs, at 37°C. After 24 hrs, the excess cement that had extruded from the open side of the root canal was removed by grinding on an Ecomet grinder (Buehler Ltd., Lake Bluff, IL). This also flattened the post on that side of the specimen (Figs. 2C and 2D). The root was then attached to an Isomet saw (Buehler Ltd.), to create 4-6 cross-sections about 1 mm thick (Figs. 3A and 3B). These were then further trimmed with the Isomet saw using a "table-saw" attachment to create a section of root dentin with a cross-sectional area of approximately 1x1 mm (although all specimen dimensions were carefully measured to the nearest 0.01 mm using a digital micrometer). This known surface area was bonded directly to the post and was aligned vertically on a microtesting guide (Ciucchi device) which insured the application of pure tensile stress (Fig. 3D).

Experimental Groups

There were five groups: Group 1 was treated with Primabond 97 primer and the post was cemented with the Primabond Resin Cement. The primer light-cured; Group 2 used the same materials but the primer was mixed with an activator to make it self-cured; Group 3 specimens were cemented with Primabond Resin Cement but not treated with primer; Group 4 specimens were treated with A-D primer and Panavia 21 (Kuraray, Osaka, Japan); Group 5 specimens were cemented with Panavia 21 without primer treatment.

The manufacturer's instructions were followed for all materials. For Primabond 97, the root canal was etched for 10 sec with the acid that was provided. (We recommend that practitioners use endodontic irrigating needles (with lateral perforations) for rinsing the canal with water to adequately remove any reaction products from the deepest regions of the prepared space. Similarly, the excess water should be aspirated from the canal with appropriate endodontic aspirators, followed by use of absorbent paper points).

Prismabond 97 was applied to the etch canal with a disposable brush and allowed to sit undisturbed for 15 sec. The solvent was then removed with air for 15 sec and the light-cured for 20 sec (in Group 1) or allowed to self-cure (Group 2). A second layer of primer was applied in both groups 1 and 2).

Equal volumes of base plus catalyst paste were expressed from their respective syringes, mixed and carried to the root canal with a plastic instrument. (One of the reasons that we elected to prepare the root canals in a semi-open manner was to insure that we could properly etch, rinse, apply primer and coat the entire canal with resin cement without concern about whether or not these events were being done correctly. That is, we could directly visualize whether the resin cements were coating the canal walls or not. Although this deviates from clinical practice, it insures that each step was done under ideal conditions in a clinically relevant manner).

Bond Strength Testing

Four to 8 horizontal slices, approximately 1 mm thick, were made of each tooth, perpendicular to the inserted post (Figs. 3A and 3B). These slices were then prepared by means of an Isomet saw, to form a square cross-section (approximately 1 mm wide at their narrowest (Fig. 3C). These trimmed specimens were then attached to a Vitrodyne testing machine with a cyanoacrylate adhesive (Fig. 3D).

Statistics

After calculating descriptive statistics, a Kruskal-Wallis one-way analysis of variance on ranks was performed to determine if any groups were significantly different at $\alpha = 0.05$.

RESULTS

All of the specimens in Groups 3 and 5 (those specimens which were not primed) debonded during specimen preparation and could not be tested. From previous experience with a wide variety of materials, we believe that those specimens had bond strengths of < 5 MPa.

Specimens treated with Primabond 97 primer or Panavia 21 ED primer (Group 1, 2 and 4) all survived specimen preparation and were able to be tested. The results are shown in Table 1.

The bond strength of Group 1 (Primabond 27 light-cured, plus the self-cured resin cement) was 19.9 ± 8.8 MPa. Group 2 (Primabond 27 that was self-cured by addition of an activator, plus the same experimental self-cured resin cement) gave a slightly lower mean bond strength (15.7 ± 8.3 MPa) but this difference was not statistically significant ($p > 0.05$, Table 1). When Integraposts were cemented into the root canals with the same resin cement, but in the absence of a primer, (Group 3), all 15 specimens failed during specimen preparation indicating that they had a relatively low bond strength.

Panavia 21 bonded specimens treated with the ED primer in the Panavia kit (Group 4, Table 1) gave a mean bond strength of 13.2 ± 9.0; this value was significantly lower than the light-cured Primabond group ($p < 0.05$) but was not different from the self-cured version of Primabond 97. Group 5 specimens (Panavia 21 without primer) all failed during specimen trimming (16 our of 16) indicating low bond strengths.

All of the bond failures occurred adhesively between the resin-cement and the root dentin. That is, the bond strength of the resin-cement to the titanium posts were stronger than the bond between dentin and resin.

DISCUSSION

Group 1 was included to permit comparison between the bond strengths of the light-cured and self-cured (Group 2) versions of the experimental resin cement (Primabond 97 system) even though the resin cement is to be used in its auto-cure mode clinically. It is encouraging to note that the bond strengths developed by both versions were not statistically different. Although there was a significant difference between the bond strength of the Group 1 and Group 4 (i.e. between light-cured Primabond 97 and Panvia 21 with primer), there was no difference between Panavia 21 and the self-cured version of Primabond 97. That is, the experimental resin cement is equivalent to Panavia 21.

It should be emphasized that the bonding that was done in this study was not done exactly as is done clinically. Had we seated the post into an intact root canal that did not contain a longitudinal slot, higher pressures might have developed that were sufficient to force the resin cement against the root dentin. Thus, before abandoning attempts to cement posts without primer application to dentin, another study should be conducted to confirm these preliminary results.

TABLE 1: Summary of bond strengths

Groups	Tensile bond strength values in MPa, mean ± S.D. (N)
Group 1 (Light-cured Primabond plus resin-cement)	19.9 ± 8.8 (18)
Group 2 (Self-cured Primabond plus resin-cement)	15.7 ± 8.3 (15)
Group 3 (Self-cured resin cement but no primer)	N.D. (15)
Group 4 (Self-cured Panavia 21 with ED Primer	13.2 ± 9.0 (16)
Group 5 (Self-cured Panavia 21 but no primer)	N.D. (16)

Groups connected by vertical lines in the same plane are not significantly different ($p > 0.05$). N.D. = not determined; (N) = number of specimens.

REFERENCES

Pashley DH, Sano H, Ciucchi B, Yoshiyama M, Carvalho RM. Adhesion testing of dentin bonding agents. A review. Dent Mater 11: 117-125, 1995.

Sano H, Shono T, Sonoda H, Takatsu T, Ciucchi B, Carvalho RM and Pashley DH. Relationship between surface area for adhesion and tensile bond strength - Evaluation of a microtensile bond test. Dent Mater 10: 236-240, 1994.

Smith DC and Cooper WEG. The determination of shear strengths. A method using a micro-punch apparatus. Brit Dent J 130: 333-337, 1971.

Van Noordt R, Cardew G, Howard IC, Noroozi S. The effect of local interfacial geometry on the measurement of the tensile bond strength to dentin. J Dent Res 70: 889-893, 1991.

Van Noordt R, Howard IC, Cardew G. A critique of bond strength measurements. J Dent 17: 61-67, 1989.

Versluis A, Tantbirojn D, Douglas WH. Why do shear bond tests pull out dentin? J Dent Res 76: 1298-1307, 1997.

FIGURE LEGENDS

Figure 1 Schematic illustration of how the root canal was prepared prior to insertion of the post. A = intact tooth, B = after removal of crown, C and D = preparation of post space with drill, E = cleaning post space with brush.

Figure 2 Schematic illustrating how the root was flattened on one side (A and B) to permit access to the post space. This permitted direct visualization of how well the cement was applied and distributed during cementation (C). D = removal of top of post and grinding of post to create flat surface.

Figure 3 Schematic illustration of multiple cross-sections of post in the canal (A). Each single section (B) was then sectioned (C) to create a short stick of root dentin bonded to the post (D). The opposite ends of the specimen were then fixed to flat stainless steel supports using cyanoacrylate cement, and then placed under tensile load to failure.

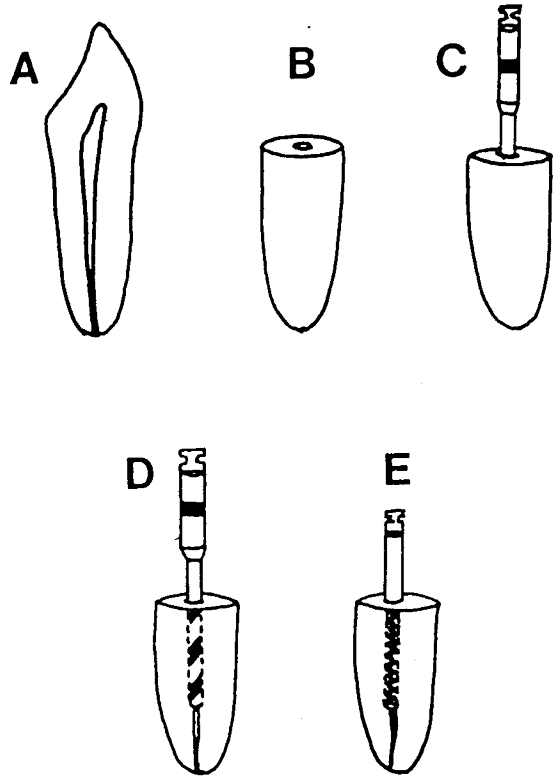

Fig. 1

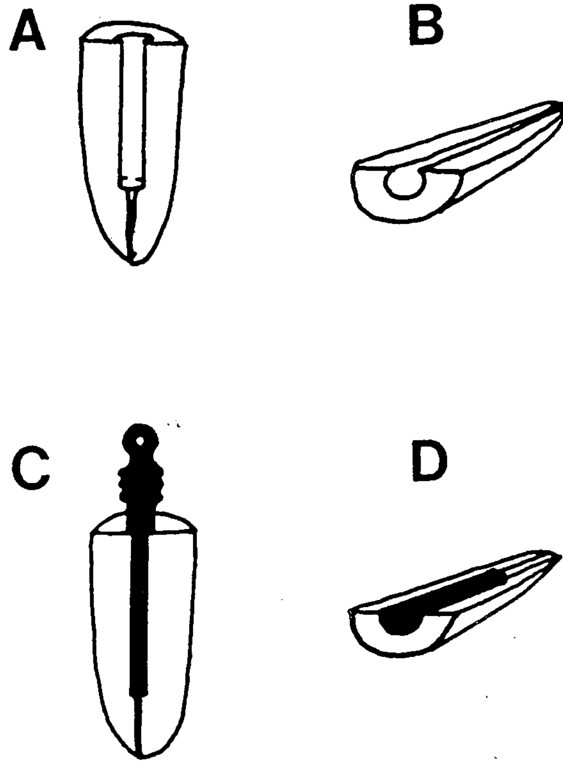

Fig. 2

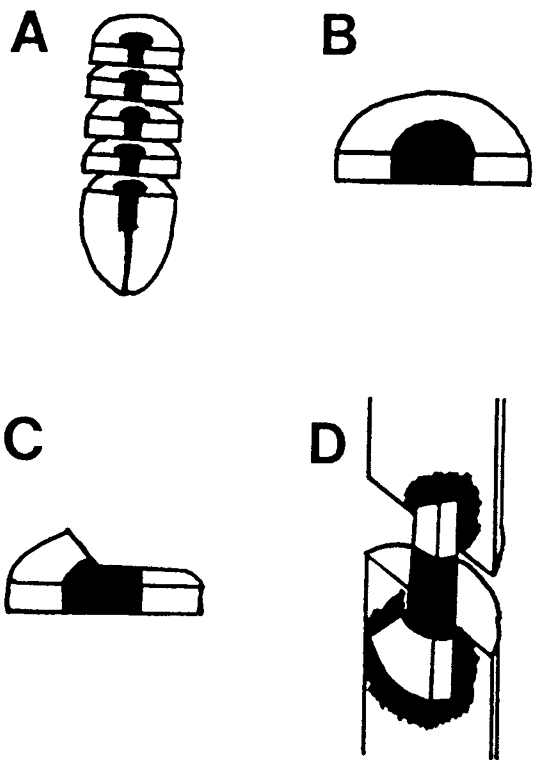

Fig. 3

HYBRIDIZATION OF DENTAL HARD TISSUES

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