A New Orthodontic Bonding Adhesive

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Orthodontic brackets have traditionally been bonded with composite resin materials, either chemically or light-cured.[1,2] Composite resins have several drawbacks, however, including moisture sensitivity,[3] potential allergic reactions,[4] and taste.

For nearly 20 years, cyanoacrylate glues have been widely used in dentistry as well as in medicine.[5] A number of studies have found no adverse affects from long-term use of cyanoacrylates inside the human body.[6,7] In 1991, a commercially available ethyl-cyanoacrylate material was tested as an orthodontic bracket adhesive and found to have significantly higher tensile strength than a conventional composite.[8] After 50, 100, and 150 days in a saline solution, the cyanoacrylate showed no decline in tensile strength.

The aim of the present study was to compare a new ethyl-cyanoacrylate adhesive (SmartBond*) to established composite bonding materials in terms of shear bond strength and debonding effects.

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†††Lloyd Instruments, Fureham, England.

Materials and Methods

Two hundred sixty extracted premolars were stored in water at 4°C. Each extracted tooth was embedded in a mold in hard plaster, with the buccal surface of the tooth visible above the plaster. The visible enamel was inspected under a microscope to avoid including test samples with enamel fractures from the extractions.

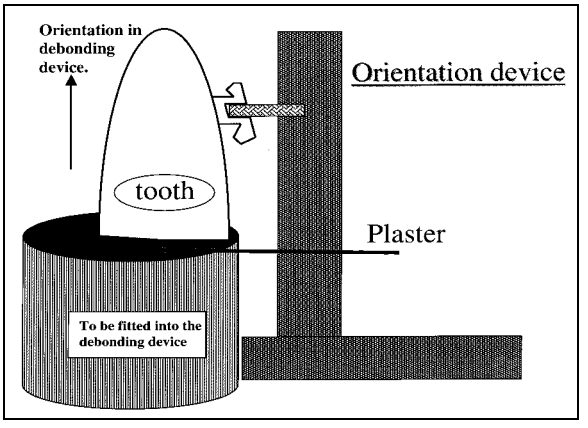

Fig. 1 Orientation device for bonding brackets.

TABLE 1
BRACKETS TESTED

Stainless steel
Omniarch‡
Edgeway†
Discovery††
Polycarbonate
Image*[1]
Elan‡[2]
Aesthetic-Line‡‡
Spirit§[2]
Silkon§§[1]

1 = Extensive enlargement of retention area.
2 = Metal slot insert.

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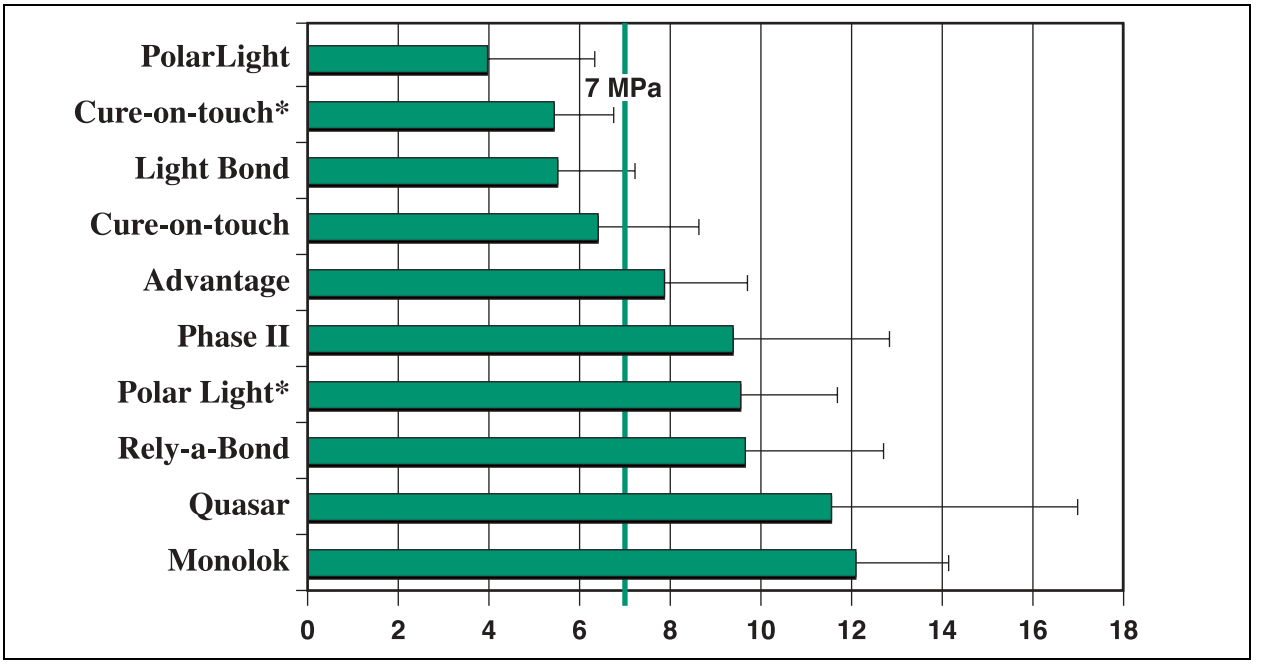

Fig. 2 Mean shear bond strengths (MPa) and standard deviations for eight adhesives to .022"Image brackets (*primer used).

Prior to the analysis of the cyanoacrylate adhesive, an evaluation of the shear test method was performed using Rely-a-Bond** composite resin. Rely-a-Bond, which was chosen because it is widely used in orthodontics, was compared to three light-cured composite resins—Cure-on-touch,*** Polar Light,* and Light Bond**—and four chemically cured adhesives—Phase II,** Quasar,**** Monolok,**** and Advantage.†

The enamel surfaces of the extracted teeth were etched for 20 seconds, following the manufacturer's recommendation for Rely-a-Bond. Fiberglass-reinforced polycarbonate .022" brackets (Image*) were bonded, using an orientation device to ensure that the brackets were identically placed on the buccal surfaces (Fig. 1).

Ten teeth were bonded with each adhesive. The chemically cured materials were allowed to set for 24 hours in 100% humidity at 35°C. The light-cured materials were cured for 60 seconds, then stored for 24 hours in 100% humidity at 35°C.

A Lloyd LRX††† dynamic testing machine was used to measure shear strength at debonding. No signs of damage to the enamel, such as fractures or infractions, could be observed under the microscope. Rely-a-Bond's shear strength was well above the 7 MPa level, which is regarded as a minimum for clinically effective bonding[9] (Fig. 2). Therefore, Rely-a-Bond was found to be a representative composite for comparison to SmartBond, using both metal and polycarbonate brackets.

The enamel surfaces of the remaining 160 samples were etched as follows: 10 seconds for each tooth bonded with SmartBond, or 20 seconds, following the manufacturer's instructions, for each tooth bonded with Rely-a-Bond. Eight

different brackets were tested with each adhesive on 10 teeth each (Table 1).

Any brackets with enlarged retention areas or undercuts were pretreated with water before bonding with SmartBond, which is delivered in a gel form. Otherwise, unreacted cyanoacrylate would have remained in the undercuts, leading to a deterioration in the bracket bases. Because the setting of the cyanoacrylate is initiated by pressure and moisture, the surfaces of the etched enamel were completely covered with water just prior to bonding, and slight pressure was applied with a probe for one or two seconds.

The brackets were bonded using the same orientation device, and excess adhesive was removed immediately. In preliminary clinical tests, SmartBond reached an acceptable shear strength after two to three minutes, but did not achieve its maximum strength until after 24 hours. Therefore, all samples were allowed to set for 24 hours in 100% humidity at 35°C, as in the earlier method evaluation.

Any further excess of the cyanoacrylate adhesive that had appeared after 24 hours was not removed prior to debonding. Shear bond strengths were measured with the Lloyd LRX dynamic testing machine.

The Adhesive Remnant Index was recorded for each sample as follows:
5 = 0% adhesive remaining on the tooth
4 = 1-9% remaining
3 = 10-90% remaining
2 = 91-99% remaining
1 = 100% remaining

Debonding effects were also observed under the light microscope.

A Student t-test was used for the bond strength analysis, since the differences in strength values were pronounced. For the ARI analysis, a Wilcoxon signed rank test was used, with the level of significance at .01.

Results

Although Rely-a-Bond was found to have a clinically adequate shear bond strength, SmartBond's strength was significantly higher ($p < .001$) for the brackets tested (Fig. 3). The mean bond strengths of Rely-a-Bond did not differ significantly among the eight different brackets.

On brackets with enlarged retention areas (Image and Silkon), the cyanoacrylate was only 60% stronger than the composite resin, even though the bases had been pretreated with water. Gaps between the bonded surfaces appeared to reduce the shear strength, as evidenced by the fact that the Elan bracket, with an almost completely smooth base, showed the highest mean bond strength.

The cyanoacrylate reacted similarly to the composite resin in debonding. With Elan and Silkon brackets, virtually no cyanoacrylate material was left on the enamel, indicating adhesive fracture between the enamel and the material (Fig. 4). Only with Omniarch and Discovery (both metal brackets) did SmartBond show a significantly lower ARI than Rely-a-Bond. Since no recorded values were as high as 5, however, the ARI analysis indicated no risk of debonding damage to the enamel from either adhesive. In fact, no signs of enamel fractures or other damage to the enamel could be observed under the light microscope.

Discussion

Cyanoacrylate is widely used as "super glue" in the manufacture of automobiles, circuit boards, and light aircraft. In medicine, it has also been used for fracture fixation,[10,11] skin sutures,[12] cardiac surgery,[5] guided tissue regeneration,[13] and circumcision of children.[6] SmartBond is not the same as the glue that can be bought in a hardware store; its viscosity has been altered with silica gel, and the product has received FDA approval in the United States and a CE-mark for Europe.

Because polymerization starts only in the presence of moisture and pressure, the clinical procedure for bonding with SmartBond differs from that of conventional adhesives. Clinical experience indicates that cyanoacrylate does not work well on polycarbonate brackets with enlarged retention surfaces unless they are pre-

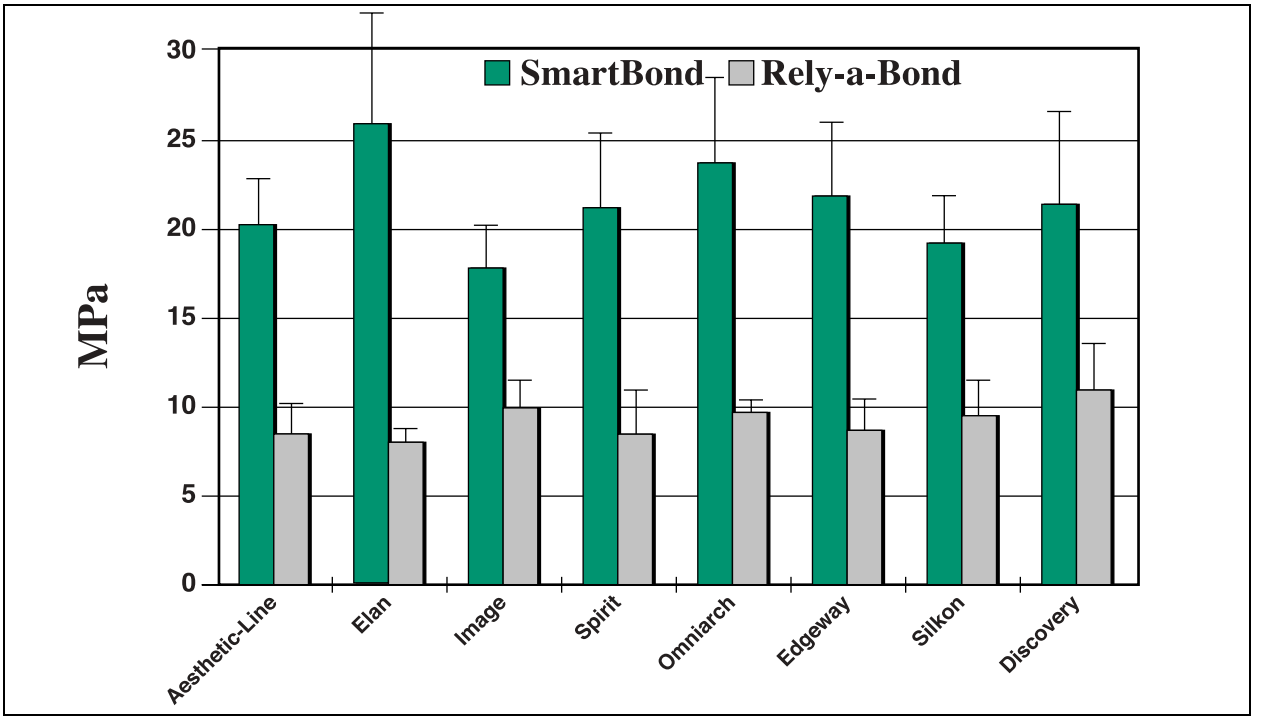

Fig. 3 Mean shear bond strengths and standard deviations in MPa (N/mm²).

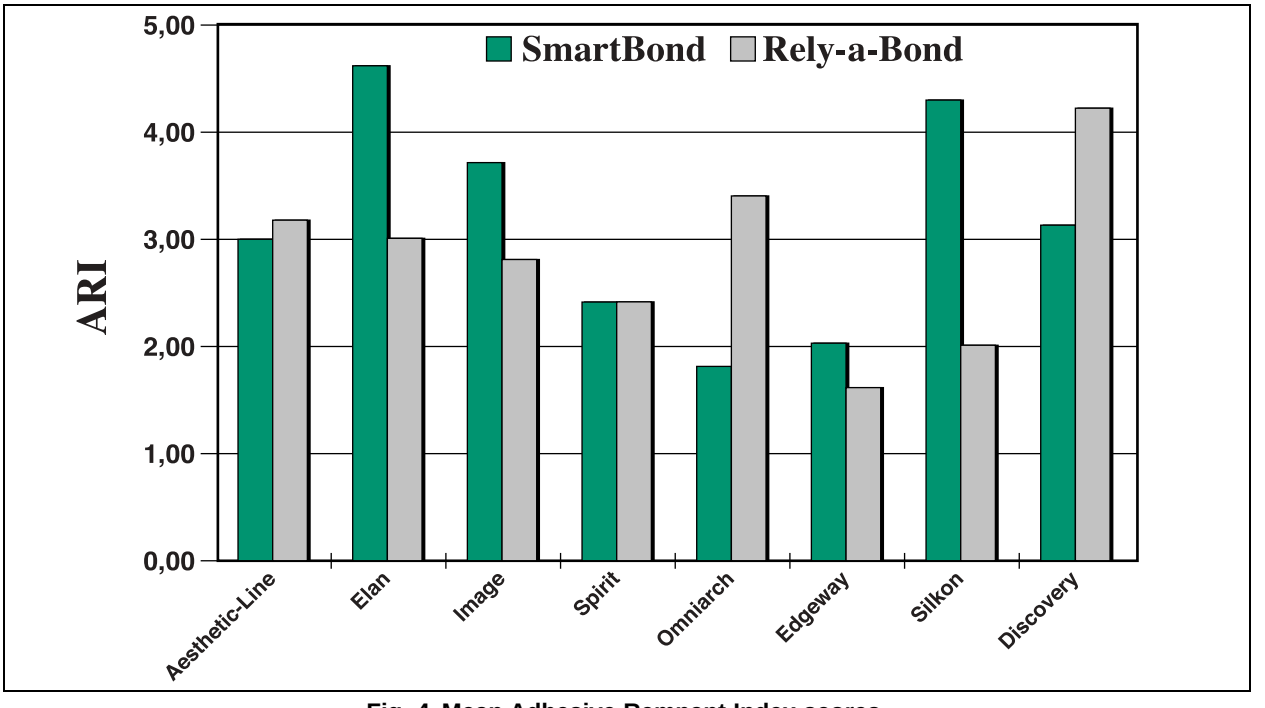

Fig. 4 Mean Adhesive Remnant Index scores.

treated with water. The excess material will be instantly polymerized and turn into a white acrylic powder around the bracket, called "blooming".

It is also important that the surfaces to be bonded are as close together as possible. The material cannot fill spaces or gaps, which is why a bracket base with deep mesh or undercuts will have a lower bond strength.

There are no reports of allergic reactions or biocompatibility problems with the present formula of cyanoacrylate. Although toxic eczema has been observed among fingernail sculptors,[14] these artists use a variety of materials, and it seems likely that the problems reported were caused by methacrylate substances.[15]

The familiar cyanoacrylate vapor is unlikely to be noticed by either the orthodontist or the patient. Vapor from the unpolymerized material is immediately polymerized when it comes in contact with water, which also eliminates any taste. No residual monomer can react later in the process, and thus no water is absorbed by the material. This is probably the reason why the adhesive does not discolor during treatment.

Conclusion

Significantly higher shear bond strengths were recorded for SmartBond than for a widely used composite resin, corroborating the findings of an earlier study.[8] Remnants of the two adhesives on the enamel surfaces were similar, with most fractures occurring within the adhesives. Therefore, this study indicates that SmartBond presents no particular danger of fracturing the enamel during debonding.

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