APC™ PLUS Adhesive Coated Appliances: A Bonding Study
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The APC™ PLUS Adhesive Coated Appliance System provides the efficiency of the APC™ Bonding System which orthodontists have come to know and appreciate. For example, each bracket is precoated with a consistent amount of adhesive, meaning no mixing, no application and no opportunity to contaminate the base. In addition, the APC PLUS System offers new features. It is fluoride releasing and provides a color change feature which gives the clinician a visual marker of adhesive placement, especially convenient during flash clean-up. Upon light curing with any standard halogen light, plasma arc system or LED system used for dental or orthodontics, the photobleachable dye fades (recommended curing times from the light manufacturer should be used).

APC™ PLUS Adhesive
The APC™ PLUS Adhesive contains hydrophilic monomers. Fluoride release is partially dictated by the ability of the adhesive to provide aqueous diffusion into and out of the cured, crosslinked matrix. An acidic oligomer (a carboxylated methacrylate) is also part of the fluoride release mechanism. Fillers include silica and a fluoridoalumino-silicate glass (FAS), which is the fluoride source. There is a small amount of BisGMA in the adhesive in addition to a rheology modifier. In contrast, APC™ II Adhesive does not release fluoride and is a fully hydrophobic adhesive, BisGMA being one of the major resin components.

Fluoride Release
Fluoride release was measured for several systems and compared to APC PLUS adhesive. APC PLUS adhesive, being a compomer in the same class as F2000 restorative, releases fluoride to approximately the same degree and less than a glass ionomer such as Fuji Ortho LC. Fluoride release was measured through 90 days and the average daily fluoride release rate in micrograms per gram sample per day was recorded. Each day the distilled water was changed and a fluoride probe was used for analysis. Figure 1.

![Figure 1: Average Daily Fluoride Release](image-url)
**Bond Strength Studies**

Shear peel bond strength studies compared APC™ PLUS and APC™ II Adhesives with 30 ea. SmartClip™ Self-Ligating UL Central Brackets (REF. 3004-301 or 5004-301 for APC II or APC PLUS Adhesive, respectively). Adhesive precoated brackets were bonded to bovine teeth which had been prophied, then rinsed, and etched/primed with Transbond™ Plus Self Etching Primer (REF. 712-090, lot 162732-L6C). An Ortholux™ LED Curing Light was used to cure the brackets with a 5 X 5 second cure. The bonded teeth were stored overnight in 37°C water. Bond strength was tested in shear/peel mode using an MTS QTest/5 with TestWorks®4 software (MTS Systems, Eden Prairie, MN).

APC PLUS Adhesive yielded statistically higher bond strengths than APC II Adhesive for SmartClip brackets (p = 0.000). Statistical analyses were performed using one-way ANOVA. All bond strengths are considered clinically acceptable. Clinical results may vary slightly. (See Figure 2).

**Indirect Bonding with APC™ PLUS Adhesive**

In the indirect method, the orthodontic adhesive is cured on the stone model and then subjected to numerous processing steps, including tray removal, cleaning, and multiple rinsing steps. It has already been demonstrated that APC II adhesive functions effectively within the Sondhi™ Indirect Bonding System. It would be useful to benchmark the performance of APC PLUS adhesive with that of APC II adhesive using the same technique. In the present study, APC PLUS and APC II adhesive pre-coated metal brackets were bonded to bovine teeth using the Sondhi indirect bonding method, and pull testing conducted to measure bond strength.

**Materials and Methods**

6 patient models (with 8 teeth per model) were prepared by embedding bovine teeth into Whip Mix White ADA Type III Orthodontic Stone.

Negative impressions of the models were formed by filling Unitek™ Disposable Impression Trays with 3M™ ESPE™ Position™ Penta™ Quick Impression Material and setting the models into the impression filled trays. Finally, models were removed from impression material and then dammed with 3M™ ESPE™ Express™ STD impression putty. Negative impressions were filled with orthodontic stone and left to harden for 30 minutes. Stone models were removed and placed into a 40°C oven overnight. Following oven drying, models were coated with one coat of a 1:4 diluted Dentsply Al-Cote® separating solution. Models dried for 1 hour at room temperature.

APC II Victory Series™ upper lateral Brackets (REF. 3017-877) and APC PLUS Victory Series™ Low Profile upper lateral Brackets (REF. 5024-877) were seated onto the stone models in an alternating fashion, and the flash removed for each. Note that the Victory Series Low Profile brackets are different from standard Victory Series brackets, but the mesh bases are similar.

Primary curing of brackets took place for 10 minutes in the Dentsply Triad® 2000™ curing device. PAM™ cooking spray was applied over the models/brackets and inside a generic polycarbonate hard tray. The hard tray was then filled with Heraeus Kulzer Memosil™ II impression material and placed over the brackets making sure the brackets were fully embedded into impression material. Brackets were separated from stone models when hard/soft trays were removed. Secondary curing of brackets took place for an additional 2 minutes in the Dentsply Triad 2000 curing device. Trays were positioned in Triad to allow brackets to be exposed to the light.

Trays were placed into a mixed beaker of 4 drops Ivory™ Ultra dish washing liquid and 500 mL distilled water. The trays were sonicated with a Cole-Parmer 8890 Sonicator for 5 minutes. Next, trays were removed and placed into a clean beaker filled with 500 mL distilled water and again sonicated for 5 minutes. Finally, trays were removed and briefly rinsed with a stream of distilled water before being dried with an air gun. A Danville
Microetcher™ and 3M™ ESPE™ CoJet™ Sand were used to sandblast the base of the brackets for approximately 1-2 seconds using roughly 50% of the force needed to expel the sand. Trays were briefly rinsed with distilled water and dried with an air gun.

Teeth from the patients’ model were etched with Transbond™ XT Etching Gel, then rinsed and dried. Sondhi™ Rapid-Set Resin A was applied to the tooth and Sondhi™ Rapid-Set Resin B was applied to the bracket. Soft trays were sectioned and positioned over teeth. Pressure was applied to teeth for 1 minute and 10 additional minutes elapsed before the soft tray was removed.

After curing, teeth were placed in a 37°C water bath overnight. Teeth were individually mounted in a cold-cure denture base acrylic resin. Samples were mounted onto a test fixture with the gingival edge up. A round 0.02 in. stainless steel wire (3M Unitek) was looped beneath the occlusal tie wings. The other end of the wire is gripped by an upper jaw of the MTS test machine. A shear- peel crosshead speed of 0.2 inch/minute was then used to debond each bracket specimen. Pull tests were conducted over three consecutive days to account for day-to-day variability.

Results

The comprehensive bond strength data for APC™ PLUS and APC™ II Victory Series Low Profile Brackets bonded onto bovine teeth using the Sondhi™ Indirect Bonding method are shown in Figure 3, below. APC PLUS and APC II adhesives both display bond strengths in the range of 20-40 lbs/bracket, or 10-20 MPa. These measured values are well within the clinically acceptable range for bonded orthodontic appliances.

Moreover, this data demonstrates that APC PLUS adhesive coated brackets bonded to bovine teeth using the Sondhi indirect bonding method are not significantly different in bond strength compared to similar APC II adhesive coated bracket samples.

This was verified in a one-way ANOVA, which yielded a p-value of 0.33. This is greater than 0.05 and therefore indicates that the APC PLUS and APC II adhesive coated appliances display statistically equivalent bond strength.

Conclusions and Recommendations

Laboratory testing has revealed no significant difference in bond strength observed between APC PLUS and APC II adhesive coated upper lateral brackets bonded to bovine teeth using the Sondhi indirect bonding method. However, since the APC PLUS adhesive contains hydrophilic components, when used for indirect bonding, the custom resin base may appear visually different than when APC II adhesive is used. A white oxygen-inhibited layer may appear on the surface of the custom resin base (that can be microetched).

Given the technique-intensive nature of indirect bonding and the hydrophilic nature of APC PLUS adhesive, it would be helpful to review some of the critical steps in this study:

- The stone model should be sufficiently dry prior to tray preparation, preferably dried overnight.
- To obtain a thorough cure of the custom resin base, it is important to perform a secondary cure after the brackets are removed from the stone model and before re-soaking in water.
- The custom resin base should be thoroughly microetched to clean the bonding surfaces.

If these steps are carefully followed, APC PLUS and APC II adhesive should both provide a high rate of success using the indirect bonding method.

REFERENCES


Figure 3: Bond strength chart comparing APC™ PLUS and APC™ II Adhesives on Victory Series™ Low Profile Brackets (n=60).