EFFECTS OF THREE ADHESION BOOSTERS ON THE SHEAR BOND STRENGTH OF NEW AND REBONDED BRACKETS—AN IN VITRO STUDY

Aim: To evaluate the effects of three adhesion boosters—All-Bond 2, Enhance LC, and Ortho Solo—on the shear bond strength of new and rebonded (previously debonded) brackets. Methods: One hundred new and 100 sandblasted debonded brackets were bonded to 200 extracted human premolars and divided into eight groups. Results: The new brackets/Ortho Solo group yielded the highest bond strength, followed by the new brackets/All-Bond 2 and the new brackets/Enhance LC groups. During rebonding, Ortho Solo improved the bond strength significantly; however, All-Bond 2 and Enhance LC did not. Conclusion: (1) Bond strength is significantly improved when new brackets are bonded with an adhesion booster; (2) without any adhesion booster, sandblasted rebonded brackets yield a significantly lower bond strength than new brackets; (3) Enhance LC failed to improve the bond strength of rebonded brackets; (4) Ortho Solo increased the bond strength of rebonded brackets significantly; and (5) brackets rebonded with Ortho Solo yielded comparable bond strength as new brackets without any adhesion booster. World J Orthod 2010;11:123–128.

Key words: adhesion boosters, rebonding, shear bond strength

In previous decades, advances in the development of orthodontic adhesives greatly increased the efficiency of bonding brackets (and other attachments). However, bond failure is still among the most frustrating occurrences in orthodontic practice. Studies have shown that such failures occur in about 5% to 7% of patients with brackets. In addition, clinicians may intentionally debond brackets during orthodontic treatment to rebond them in a superior position. Thus, rebonding of brackets is common during orthodontic treatment.

Repeated bond failure in a single tooth is of particular clinical concern. Mizrahi stated that the initial failure rate is 4%, which increases to 14% after rebonding and 25% after a second rebonding. One of the main causes for an increased failure rate could be an alteration of the enamel (adhesive remnants) in conjunction with the repeated bonding.

Bishara et al found that rebonded brackets had an inconsistent and significantly lower shear bond strength. They suggested the use of an adhesion booster to improve bond strength. Adhesion promoters (boosters) are multifunctional molecules that adhere chemically to the enamel and at the same time interact with the resin.
The aims and objectives of this study were:

- To find out whether there is any significant difference in the shear bond strength between initial bonding and rebonding
- To find out whether there is any significant difference in shear bond strength when using an adhesion booster during initial bonding and rebonding
- To compare the effect of three adhesion boosters (All-Bond 2, Enhance LC, and Ortho Solo) on initial bonding and rebonding

METHODS AND MATERIALS

Two hundred human maxillary first premolars extracted for orthodontic purposes with intact buccal enamel were cleaned of tissue debris and stored in distilled water with 0.1% thymol crystals to inhibit bacterial growth. The bonded attachments were stainless steel, preadjusted edgewise brackets, Roth prescription, with 0.022-inch slots for maxillary premolars with a foil-mesh base (surface area 9.8 mm²) (Gemini, 3M Unitek). These were placed along the crown axis by one operator. The adhesion boosters tested were: All-Bond 2 (Bisco), consisting of a primer A (Na-N-tolylglycine glycidylmethacrylate, acetone, and ethanol) and a primer B (biphenyl dimethacrylate, acetone, and ethanol); Enhance LC (Reliance), composed of HEMA (hydroxyethyl methacrylate), tetrahydro-furfuryl cyclohexane dimethacrylate and ethanol; and Ortho Solo (Ormco), consisting of ethyl alcohol, alkyldimethacrylate resin, barium aluminoborosilicate glass, silicon dioxide, and sodium hexafluorosilicate.

All teeth were embedded in acrylic resin approximately to the level of the cementoenamel junction and stored in an airtight, humid environment to prevent dehydration. One hundred of the 200 teeth were randomly assigned to the following four groups of 25 teeth each: group A, new brackets/no adhesion booster; group A1, new brackets/All-Bond 2; group A2, new brackets/Enhance LC; and group A3, new brackets/Ortho Solo.

The remaining 100 teeth were etched and bonded with brackets using Light Bond (Reliance). After careful removal of all bonding material excess, they were light cured for 10 seconds with an Elipar light-curing unit (3M Unitek) on each of the four sides. These brackets were subsequently separated with debonding pliers using light pressure from the respective teeth. While debonding, care was taken to prevent distortion of the bracket bases.

These bases were sandblasted with a microetcher at 65 psi for 7 to 12 seconds with 50μm aluminum oxide particles and inspected under 100X magnification to be certain that all visible adhesive was removed. Each sandblasted bracket base was then wiped with acetone on a cotton pledget and dried with air. The residual composite on the teeth was removed with a no. 12 fluted tungsten carbide bur using a high-speed air rotor handpiece until no resin was apparent on visual inspection.

The teeth were then cleaned at slow speed with a prophy cup and a non-fluorided oil-free pumice paste, rinsed with water, and dried with oil-free air. The enamel was etched with 37% phosphoric acid for 15 seconds, rinsed again, and air dried. These 100 teeth were divided into the following four groups of 25 teeth each: group B, rebonded brackets/no adhesion booster; group B1, rebonded brackets/All-Bond 2; group B2, rebonded brackets/Enhance LC; and group B3, rebonded brackets/Ortho Solo.

All group A teeth were thinly coated with Light Bond sealant, which was light cured for 10 seconds; Light Bond paste was applied to the bracket base. The slightly moist enamel of all teeth in group A1 was thinly (4 to 5 brush strokes) coated with a mixture of All-Bond 2 primer A and B according to the manufacturer’s recommendation. This coat was lightly dried until it looked glossy. A thin layer of Light Bond sealant was then applied directly on the All-Bond 2 coat and light cured for 10 seconds. Light Bond paste was applied to the bracket base.

All teeth in group A2 were thinly (4 to 5 brush strokes) coated with Enhance LC and lightly dried according to the manufacturer’s recommendation. A thin layer of Light Bond sealant was then applied
directly on the Enhance LC coat and light cured for 10 seconds. Light Bond paste was applied to the bracket base.

All teeth in group A3 were thinly (4 to 5 brush strokes) coated with Ortho Solo, and the bracket was directly bonded with Light Bond paste. According to the manufacturer, Ortho Solo itself primes the enamel when light cured.

All teeth in group B were thinly coated with Light Bond sealant, which was light cured for 10 seconds. Light Bond paste was applied to the sandblasted bracket base.

The slightly moist enamel of all teeth in group B1 was thinly (4 to 5 brush strokes) coated with a mixture of All-Bond 2 primer A and B according to the manufacturer’s recommendation. This coat was lightly dried until it looked glossy. A thin layer of Light Bond sealant was then applied directly on the All-Bond 2 coat and light cured for 10 seconds. Light Bond paste was applied to the sandblasted bracket base.

All teeth in group B2 were thinly (4 to 5 brush strokes) coated with Enhance LC and lightly dried according to the manufacturer’s recommendation. A thin layer of Light Bond sealant was then applied directly on the Enhance LC coat and light cured for 10 seconds. Light Bond paste was applied to the sandblasted bracket base.

All teeth in group B3 were thinly (4 to 5 brush strokes) coated with Ortho Solo, and the sandblasted bracket was directly bonded with Light Bond paste. According to the manufacturer, Ortho Solo itself primes the enamel when it is light cured.

After bonding, all samples were stored in distilled water at room temperature for 24 hours. After being suspended from a stainless steel wire, the specimens were placed in the mounting jig of a Lloyd’s universal testing machine and loaded with a shear force in the occlusogingival direction at a crosshead speed of 1 mm/min (Fig 1). The force necessary for debonding was recorded in N and converted to MPa. Debonded specimens were randomly examined at 50× magnification to evaluate the bond failure mode, which was determined on the basis of the Adhesive Remnant Index (ARI) of Årtn and Bergland.9

**Statistical methods**

Descriptive statistics, including means, standard deviations, and minimum and maximum values, were calculated. Two-way analysis of variance (ANOVA) was used to determine any significant differences among the various groups. In case of a significant difference, a pairwise multiple comparison was performed by one-way ANOVA, followed by the Student Newman-Keuls test. The chi-square test was used to determine significant differences in the ARI scores among the groups. Significance for all statistical tests was $P \leq 0.05$. 

![Fig 1](image_url) Setup for shear bond strength test in this study (Lloyd’s universal testing machine).
RESULTS

Means and standard deviations of all groups studied are given in Table 1 and Fig 2. In general, all groups with rebonded brackets demonstrated much lower shear bond strengths. A booster effect was apparent in only the new brackets. As Table 2 shows, a significant difference existed among all the A groups, and between groups A and B, B1 and B2, and B3 and B.

Group A3 (27.8 ± 2.9 MPa) had a significantly higher bond strength than any other group, followed by group A1 (24.9 ± 4.0 MPa) and group A2 (21.3 ± 3.7 MPa).

During rebonding, Ortho Solo improved the bond strength significantly compared to rebonding without adhesion booster.

Most of the failures in the B groups occurred at the adhesive-bracket interface, which indicates that more cleanup of the bracket base is necessary before rebonding (Table 3). The exception is group B2, which showed more bond failures toward the enamel-resin interface.
DISCUSSION

Various compounds, including polyfunctional surface-active amine accelerators, have been recommended to promote adhesion. These adhesion boosters supposedly increase the bond strength by interacting with surface metal ions and by functioning as a polymerization accelerator for dental resins.\(^{10}\) Clark et al\(^{11}\) compared bonding with a composite and an unfilled acrylic resin containing 5\% of the adhesion promoter 4-META. The latter material achieved a significantly higher bond strength through the 4-META, a bifunctional monomer exhibiting a hydrophobic methacrylate group and a hydrophilic aromatic anhydride group, which both enhance diffusion into the tooth surface.

Bishara et al\(^{5}\) found that in general, the highest shear bond strengths were obtained after bonding new brackets. Rebonded brackets showed significantly lower and inconsistent values. This is confirmed by the present study. The changes in bond strength may be related to changes in the morphology of the etched enamel surface as a result of remaining adhesive.

Egan et al\(^{12}\) reported that the application of Enhance LC on the base of debonded brackets failed to improve rebonding strength. Chung et al\(^{7}\) evaluated the effects of Enhance LC and All-Bond 2 on new and rebonded brackets. Their results were that the new brackets/All-Bond 2 group yielded the highest strength (20.8 ± 7.5 MPa), followed by the groups new brackets/Enhance LC (18.6 ± 6.5 MPa), rebonded brackets/All-Bond 2 (17.3 ± 7.2 MPa), new brackets/no booster (16.8 ± 6.3 MPa), rebonded brackets/no booster (14.2 ± 7.2 MPa), and rebonded brackets/Enhance LC (13.6 ± 6.7 MPa). These findings are similar to the results obtained in this study, where All-Bond 2 and Enhance LC improved the bond strength of new brackets, but Enhance LC failed to show any improvement in the case of rebonding. The difference among the adhesion boosters might be attributed to their chemical compositions.

Newman et al\(^{13}\) reported that the bond strength of sandblasted new brackets was was greater when Megabond adhesion booster was used.

Vicente et al\(^{14}\) showed that the application of Ortho Solo significantly increased the bond strength when used with Transbond-XT; however, All-Bond 2 primer did not. In the present study, both adhesion boosters increased the bond strength significantly, which could be ascribed to the Light Bond sealant/paste adhesive system. Another advantage of Ortho Solo is that it makes primer application unnecessary and thereby reduces chair time.

This in vitro study cannot truly reflect the intraoral situation. Also, the universal testing machine measured the pure shear force; in the clinic, shear, tensile, and torsional forces individually or in any combination can lead to debonding. In addition, the loading of the machine is constant, whereas forces in vivo arise abruptly and fluctuate. The results reported here may therefore exaggerate the effect of adhesion boosters on shear bond strength of orthodontic brackets bonded with composite resin.

Various studies have suggested that clinical bond strengths ranging from 6 to 10 MPa are adequate.\(^{15–17}\) No reliable protocol for measuring bond strength in vivo has been described yet.\(^{18}\) The bond strengths observed in vitro may be higher than those experienced clinically.\(^{19}\) Still, in vitro studies provide a guideline for the selection of the optimal bracket-adhesive system. The high shear bond strengths in this study might also be a result of the buccal tooth surface curvature, which may have made it difficult for the operator to place the testing machine’s blade precisely parallel to the bracket base.\(^{20}\)

CONCLUSION

The six results of this study are:

1. The bond strength during initial bonding was higher than during rebonding.
2. Adhesion boosters improve the initial bond strength significantly. New brackets/Ortho Solo had the highest bond strength, followed by new brackets/All-Bond 2, and new brackets/Enhance LC.
3. During rebonding, Ortho Solo improved the bond strength significantly.

4. All-Bond 2 and Enhance LC did not improve the bond strength during rebonding.

5. ARI scores revealed a significant difference in the site of the bond failure among the groups. The cleanup procedure after debonding was easier and faster for group B2 (rebonded brackets/Enhance LC), followed by group B (rebonded brackets/no adhesion booster), and B1 (rebonded brackets/All-Bond 2).

6. Many factors that might affect intraoral bond strength are difficult to reproduce in the laboratory. Hence, in vitro studies give only a hint about the optimal bonding procedure.

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REFERENCES


