*Original Article*

# Effects of Modifying the Adhesive Composition on the Bond Strength of Orthodontic Brackets

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**Abstract:** In an attempt to save chair time during bonding, metal brackets have been precoated with the adhesive material. Although the adhesive used on the precoated brackets is basically similar in composition to that used for bonding uncoated brackets, there are differences in the percentages of the various ingredients incorporated in the material. These changes are intended to enhance specific clinical properties. The purpose of this study was to determine whether modifications in the composition of the adhesives, used on precoated and uncoated metal brackets, affect their shear bond strengths during the first half hour after bonding. This is the time span when the initial arch wires are ligated. Sixty freshly extracted human molars were bonded with three different compositions of the same basic adhesive. The teeth were mounted in phenolic rings. An occlusogingival load was applied to the brackets producing a shear force at the bracket-tooth interface utilizing a Zwick Universal Test Machine. Analysis of variance was used to compare the three adhesives. Significance was predetermined at $\leq$.05 level of confidence. The present findings indicated that the shear bond strengths of the various modifications of the adhesive used on two different precoated metal brackets were not significantly different (F-ratio = .729 and $P$ = .407) from those obtained with the conventional adhesive used on uncoated brackets. The mean values for the shear bond strengths of the two precoated brackets were: APC = 5.1 $\pm$ 1.7 MPa and APC II = 4.9 $\pm$ 2.1 MPa. The shear bond strength for the conventional adhesive used on the uncoated brackets was = 5.7 $\pm$ 2.4 MPa. All bracket/adhesive combinations tested provided clinically acceptable shear bond forces within the first 30 minutes after initial bonding. (*Angle Orthod* 2002;72:464–467.)

**Key Words:** Composite; Modifications; Metal Brackets; Shear Bond Strength

## INTRODUCTION AND LITERATURE REVIEW

In an attempt to save chair time during bonding, ceramic and metal brackets have been precoated with the adhesive material. This approach also provides for a more uniform thickness and simultaneously reduces one of the steps in the overall bonding procedure. Precoating the brackets necessitated modifications in the composition of the conventional adhesive used on uncoated brackets (L.A. Preston, personal communication, April 24,1996). In an earlier study[1] the shear bond strengths of uncoated and precoated ceramic and metal brackets were evaluated after being stored in deionized water at 37°C for a 24-hour period. The findings indicated that precoated ceramic brackets using the modified composite adhesive had similar shear bond strengths as that provided by the conventional orthodontic adhesive used on uncoated brackets. On the other hand, precoated metal brackets using the same adhesive had significantly lower shear bond strengths than those obtained with a conventional composite adhesive used on uncoated metal brackets. The results also indicated that the bracket/adhesive combinations tested provided clinically acceptable shear bond forces after 24 hours from the time of initial bonding.[1] Similar results were obtained by Sunna and Rock.[2]

The adhesive used on the precoated brackets is similar in its components to that used for bonding uncoated brackets. The differences between the two adhesives are essentially in the percentages of the different ingredients

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incorporated in the material including the filler (L.A. Preston, personal communication, April 24, 1996). More recently additional modifications were introduced in the composition of the adhesive used with the precoated orthodontic brackets to enhance its performance.[3] More specifically the viscosity of the adhesive was reduced in order to facilitate the accurate placement of the precoated bracket on the tooth by the clinician, without having to use excessive pressure on the tooth.[2] How these new modifications in the composition of the composite adhesive affect its physical properties, particularly the shear bond strength, need to be evaluated.

The purpose of this study was to determine whether modifications in the adhesive composition affected the shear bond strengths of precoated and uncoated orthodontic metal brackets, within the first half hour after bonding. This is the time span when the initial arch wires are usually ligated.

**TABLE 1.** Composition of the Three Adhesive Products Used

| Adhesive/ Raw Materials | Transbon XT and APCII | APC |
|---|---|---|
| Resins | | |
| BisGMA | 14% | 12% |
| BisGMA | 9% | 8% |
| Fillers | | |
| Silylated quartz | 77% | 80% |
| Silylated filler and submicron silica | | |
| Curatives | | |
| Camphorquinone | <1% | <1% |
| Others | <1% | <1% |

## MATERIALS AND METHODS

### Teeth

Sixty freshly extracted human molars were collected and stored in a solution of 0.1% (weight/volume) thymol. The criteria for tooth selection included intact buccal enamel, not subjected to any pretreatment chemical agents such as hydrogen peroxide, no cracks due to the pressure of the extraction forceps and no caries. The teeth were cleansed and then polished with a pumice paste and rubber prophylactic cups for 10 seconds.

### Brackets Used

Twenty uncoated metal brackets, 20 metal brackets precoated with the APC adhesive and 20 metal brackets precoated with the APC II adhesive (3M Unitek, Monrovia, CA) were used. All brackets were identical, ie, right maxillary central incisors of the Victory Series metal brackets. The average surface area for the bracket base was 11.95 $mm^2$ for the uncoated brackets and 11.84 $mm^2$ for the precoated brackets. The surface area was the average obtained from measuring five brackets from each bracket type.

### Adhesives Used

The various ingredients of the adhesive applied to the precoated brackets APC and APC II as well as that in the Transbond XT adhesive (3M Unitek, Monrovia, Calif) are presented in Table 1. The differences are essentially limited to the percentages of the various ingredients incorporated rather than in the chemical composition of the adhesive (L.A. Preston, personal communication, April 26,1996).[1,3] Specifically, the Transbond XT contains 14% Bis GMA, 9% Bis EMA, and 77% fillers (Silylated quartz and submicron Silica). On the other hand, the corresponding values for the APC adhesive used on the precoated brackets are 12%, 8% and 80% respectively. For the APC II precoated brackets, the percentage of the ingredients were identical to those in Transbond XT except for the curatives and 'others'.[3] These new changes in the composition of the adhesive, decreased its viscosity allowing the bracket to be manipulated more readily on the tooth surface during the initial stages of bracket positioning.[3] As a result, the consistency of the APC II adhesive is softer relative to the original APC, thus making it easier for the clinician to place, press and adjust the bracket on the tooth surface during bonding.

### Bonding Procedure

A 37% phosphoric acid gel was applied to the buccal surface of each tooth for 30 seconds. The teeth were then rinsed with a water spray for 30 seconds and dried with an oil free air source for 20 seconds until the buccal surfaces of the etched teeth appeared to be chalky white in color. Transbond XT orthodontic bonding system was used as the adhesive material for bonding the uncoated brackets to the enamel surface. The bonding procedure for the two precoated brackets was similar and performed according to the manufacturer's instructions.

After the bracket was properly positioned on the tooth, each bracket was subjected to 300 grams of force using a force gauge (Correx Co, Bern, Switzerland) for 10 seconds and excess bonding resin was removed using a small scaler. The bracket was then light cured for 20 seconds as recommended by the manufacturer (Ortholux XT Visible Light Curing Unit, 3M Unitek, 3M Dental Products, St Paul, Minn).

The teeth were embedded in acrylic placed in phenolic rings (Buehler, Ltd, Lake Bluff, Ill. A mounting jig was used to align the facial surfaces of the teeth perpendicular with the bottom of the mold, so that the labial surface would be parallel to the applied force during the shear test.

**TABLE 2.** Descriptive Statistics in Megapascals (Mpa) and the Results of the Analysis of Variance of the Shear Bond Strength Between an Uncoated and Two Precoated Brackets*

| Bracket/Adhesive | N | $\bar{X}$ | SD | Range |
|---|---|---|---|---|
| Uncoated + Transbond XT | 20 | 5.7 | 2.4 | 2.1–10.9 |
| Precoated APC | 20 | 5.1 | 1.7 | 2.4–8.8 |
| Precoated APC II | 20 | 4.9 | 2.1 | 1.4–9.1 |

*F-ratio = .729, $P = .407$.

**TABLE 3.** Comparisons of the Frequency Distribution of the Shear Bond Strengths of One Uncoated and Two Precoated Brackets*

| | Shear Bond Strengths in Megapascals | | |
|---|---|---|---|
| Adhesive/Bracket | <4.0 | 4–6 | >6 |
| Uncoated + Transbond XT | 6 | 5 | 9 |
| Precoated APC | 4 | 11 | 5 |
| Precoated APC II | 6 | 8 | 6 |

* $\chi^2 = 4.05$, $P = .399$.

### Shear Bond Strength Testing

Within half an hour from the initial bonding, an occlusogingival load was applied to each bracket producing a shear force at the bracket-tooth interface. This was accomplished by utilizing the flattened end of a steel rod attached to the crosshead of a Zwick Universal Test Machine (Zwick GmbH, Ulm, Germany). A computer electronically connected to the Zwick test machine recorded the results of each test in Megapascals (MPa). Shear bond strengths were measured at a crosshead speed of 5 mm/min.

### Statistical Analysis

Descriptive statistics, including the mean, standard deviation, minimum and maximum values were calculated for each group of teeth tested. Analysis of Variance was used to determine if significant differences existed between the various groups compared. The Chi Square test was used to identify significant differences in the frequency distribution in the shear bond strength among the different groups. The limits of the frequency distribution were based on the suggestion that 4–5 MPa are considered to be adequate strength to withstand orthodontic forces.[4] Significance for all statistical tests was predetermined at $P \leq .05$.

## RESULTS

### Comparisons between the precoated and uncoated brackets:

*Shear Bond Strengths* (Table 2). The results of the analysis of variance, (F-ratio = .729) comparing the 3 different adhesive compositions used on the precoated and uncoated brackets, indicated that there were no significant differences ($P = .407$) in the shear bond strengths of the three adhesive/bracket combinations tested.

*Frequency Distribution of the Shear Bond Strengths* (Table 3). The results of the $\chi^2$-*test* comparisons ($\chi^2 = 4.05$) indicated that there were no significant differences ($P = .399$) between the frequency distribution scores of the shear bond strengths of the three groups.

## DISCUSSION AND CLINICAL IMPLICATIONS

In the present study an attempt was made to determine whether modifying the composition of the adhesive used on the precoated brackets would affect their shear bond strengths. The findings indicated that precoating the brackets with the modified composite adhesives (APC and APC II) did not affect the shear bond strengths within the first half hour after initial bonding. These results indicated that the modifications in the composition of the adhesive used on the precoated brackets to adapt to specific clinical needs did not significantly influence the shear bond strength of the adhesive.

As stated earlier, the three adhesives tested contain the same ingredients, but in different percentages and this influences the clinical characteristics of the adhesive.[5] As an example, one of the changes introduced was an increase in the amount of filler (80%) in the precoated adhesive APC when compared to the amount that was present in the original Transbond XT adhesive used with the uncoated brackets (77%). The purpose for adding more filler to the adhesive was to increase its viscosity and allow the brackets to readily adhere to the tooth surface during the initial stages of bracket positioning. The increased viscosity also increased the need to press the bracket on the tooth surface to squeeze the excess adhesive from under the bracket. As a result, the new modifications introduced with the APC II were to decrease its viscosity in order to facilitate the adjustment of the bracket on the surface of the tooth. Both changes in the adhesive composition did not seem to significantly affect the shear bond strength of the various adhesive/bracket combinations tested.

## CONCLUSIONS

In the present study, the mean shear bond strengths of the various combinations of the adhesive/brackets tested within half an hour from initial bonding ranged between 4.9 and 5.7 MPa. Therefore, the modifications introduced in the composition of the composite adhesive to alter its physical properties to adapt to various clinical needs did not significantly influence its shear bond strength.

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