

Shear Bond Strengths of Plastic Brackets With a Mechanical Base

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Abstract: This study compares the shear bond strengths of plastic brackets with a mechanical base and metal brackets using two different adhesives, and examines the modes of failure using a scanning electron microscope (SEM). Forty extracted human premolars were selected for bonding. Two types of brackets: metal and plastic-Spirit MB, and two orthodontic adhesives: System 1+ and Enlight, were used. After bonding, all samples were put into a 37°C distilled water bath for 24 hours before shear bond strengths were tested. The bond strengths of the plastic brackets were significantly lower than those of the metal brackets ($P < .0001$). There was a statistically significant difference in bond strengths between System 1+ and Enlight for plastic brackets ($P < .05$), but not for metal brackets. The modes of failure predominantly occurred at the enamel/adhesive interface in the metal bracket-System 1+ group, within the adhesive in the metal bracket-Enlight and plastic bracket-System 1+ groups, and at the bracket/adhesive interface in the plastic bracket-Enlight group. (*Angle Orthod* 2002; 72:141–145.)

Key Words: Polycarbonate brackets; Orthodontic bonding

INTRODUCTION

Esthetic orthodontic appliances have been in demand for adult patients in recent years.¹ Plastic brackets made of polycarbonate and plastic molding powder were first introduced by Newman.^{2,3} The use of plastic brackets was limited because of their poor physical properties, resulting in problems such as fracture, stain, and distortion of the brackets. Lower bond strengths were also noted.^{4,5} To correct these problems, a new generation of plastic bracket with a metal slot and a mechanical base was recently introduced. Studies showed that the torque-deformation characteristics

were not clinically significant for the metal slot reinforced brackets,^{6,7} but the bond strengths of the new plastic brackets varied.^{8–11} The objectives of this study are (1) to compare shear bond strengths of plastic brackets with a mechanical base to metal brackets using two different adhesives, and (2) to examine modes of failure after debonding using scanning electron microscope (SEM).

MATERIALS AND METHODS

Human premolars were extracted for orthodontic reasons and stored at room temperature in water. The water in which the teeth were stored was changed every day before bonding. Forty premolars were selected for bonding.

Two types of brackets, metal and plastic-Spirit MB, and two orthodontic adhesives, System 1+ and Enlight, were used. All materials were products ofOrmco Co (Glendale, Calif, USA). Both types of brackets were those used for premolars in the standard edgewise technique. The metal bracket has a mesh base. The Spirit MB is a polycarbonate bracket with a metal slot and a mechanical base. The bracket base area was estimated by weighing a uniform lead foil that was applied to cover precisely the base surface of one bracket, with three measurements for each type of bracket. The average bracket base area was 9.73 mm² and 11.07 mm² for the metal and plastic brackets, respectively. System 1+ is a urethane-modified dimethacrylate resin (UDM) and a no-mix chemical curing orthodontic adhesive. Enlight is

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TABLE 1. Shear Bond Strengths (MPa) of Various Combinations of Brackets and Adhesives^a

Mean Shear Bond Strength				
SM	13.90 ± 2.73	**	*]] NS
SP	4.38 ± 1.34			
EM	14.41 ± 4.11	**		
EP	6.31 ± 1.39			

^aMPa indicates shear bond strength; SM, System 1 + resin with metal brackets; SP, System 1 + resin with plastic brackets; EM, Enlight resin with metal brackets; EP, Enlight resin with plastic brackets; and NS, not significant.

* $P < .05$; ** $P < .0001$.

TABLE 2. ARI Scores and Number of Enamel Fractures for Various Combinations of Brackets and Adhesives^a

	ARI Scores			Enamel Fractures
	1	2	3	
SM	6	4	0	5
SP	2	7	1	1
EM	2	6	2	2
EP	0	1	9	0

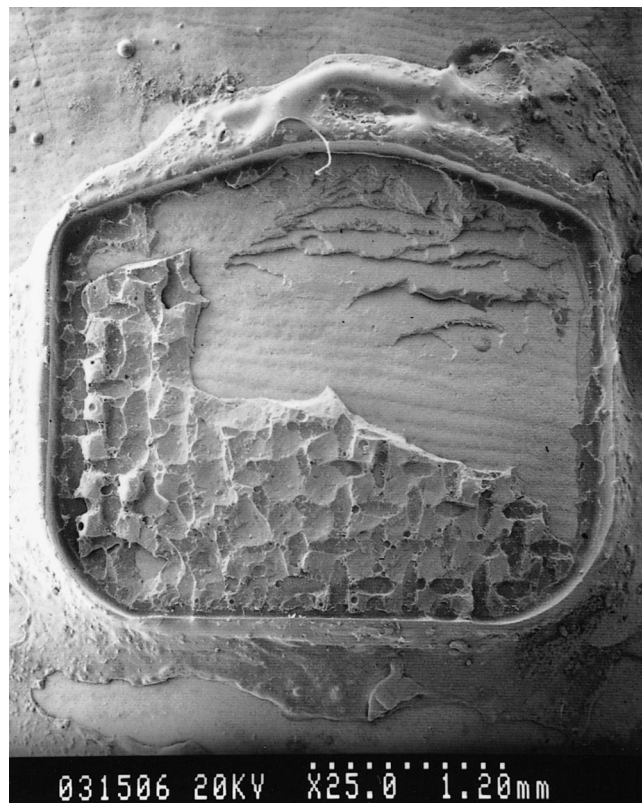
^aARI indicates adhesive remnant index; SM, system 1 + resin with metal brackets; SP, system 1 + resin with plastic brackets; EM, Enlight resin with metal brackets; EP, Enlight resin with plastic brackets; and NS, not significant.

* $P < .05$; ** $P < .005$.

a Bis-GMA resin and a 1-paste, fluoride-releasing, light-cure adhesive.

After the premolars were polished, cleaned, and air-dried, the brackets were bonded to the teeth with adhesives according to the manufacturer's instructions. The samples were divided into four groups with different combinations of brackets and adhesives. A 0.017 inch × 0.025 inch stainless steel sectional wire was put into the slot as a guide and tied by a ligature wire to the wings. The wire was placed immediately for the Enlight groups and five minutes after bonding for the System 1+ groups. Then, the teeth with the guides were embedded in die stone. All samples were put into a 37°C distilled water bath for 24 hours before the shear bond strengths were tested. A universal testing machine (AG-2000E, Shimadzu, Kyoto, Japan) was used to test the shear bond strengths of the four groups at a cross-head speed of 0.5 mm/minute. The results of the shear bond strengths of the four groups were compared by unpaired *t*-tests.

After the shear bond strengths were tested, the tooth surfaces were observed with a scanning electron microscope

**FIGURE 1.** SEM (25×) shows the enamel surface after debonding in metal bracket—System 1+ group. ARI score = 1. Enamel fracture is noted.

(Hitachi S-5000, Hitachi, Mito City, Japan) to evaluate the mode of failure at 25× magnification and enamel fracture at 150× magnification. Adhesive remnant index (ARI) scores¹² were recorded for each specimen to represent the mode of failure. A score of zero indicates no adhesive left on the tooth, one indicates less than half of the adhesive left on the tooth, two indicates more than half of the adhesive left on the tooth, and three indicates all the adhesive left on the tooth. The results of the ARI scores of four groups were compared by Wilcoxon Signed Rank test.

RESULTS

The shear bond strengths of the various combinations of brackets and orthodontic adhesives are shown in Table 1. The bond strengths of the plastic brackets were significantly lower than those of the metal brackets for both adhesives ($P < .0001$). There was a statistically significant difference in bond strengths between System 1+ and Enlight for plastic brackets ($P < .05$), but not for metal brackets.

The ARI scores and number of enamel fractures are shown in Table 2. An ARI score of one was predominantly present in the metal bracket-System 1+ group, two in the metal bracket-Enlight and plastic bracket-System 1+ groups, and three in the plastic bracket-Enlight group ($P < .05$). There were five enamel fractures in the metal bracket-

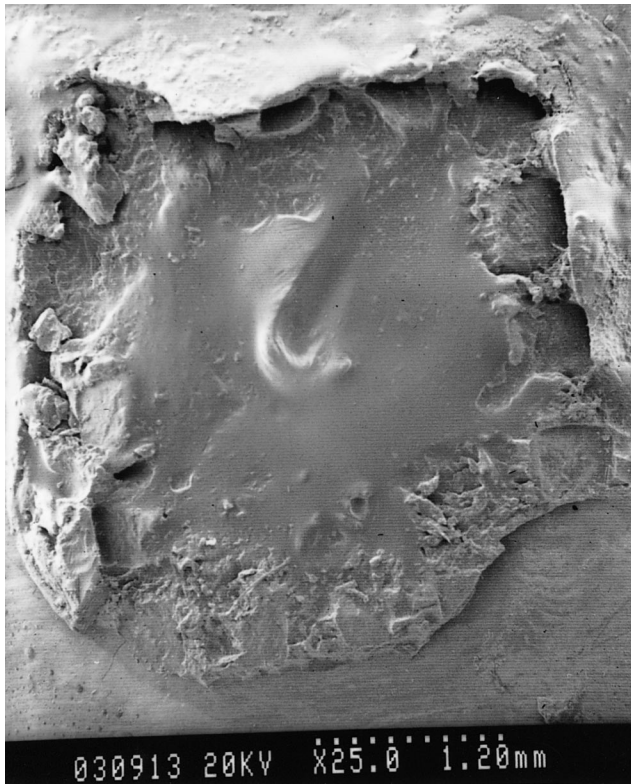


FIGURE 2. SEM (25 \times) shows the enamel surface after debonding in plastic bracket—System 1+ group. ARI score = 2. Enamel fracture is noted.

System 1+ group and none in the plastic bracket-Enlight group. An SEM at 25 \times magnification of the surface of one tooth in each group is shown in Figures 1 to 4.

DISCUSSION

The bond strengths of plastic brackets ranged from 1.4 MPa to 19.07 MPa. The differences are due to different combinations of bracket and adhesive.^{8-11,13-17} In most studies, the bond strengths of plastic brackets were significantly lower than those of metal brackets.^{8-11,13-16} The bond strength of Spirit MB ranged from 1.4 MPa to 10.3 MPa, with most values in the 3 to 6 MPa range.⁸⁻¹¹ In our study, the mean bond strengths of Spirit MB were 4.4 MPa and 6.3 MPa for System 1+ and Enlight, respectively, which showed a statistically significant difference. Most Bis-GMA adhesives provide enough bond strength for plastic brackets,^{8-11,13} whereas glass ionomer cement does not.⁸ System 1+ provided enough bond strength in one study,¹⁶ but not in another.¹¹ Reynolds stated that a minimum bond strength of 5.9 to 7.9 MPa results in successful clinical bonding.¹⁸ In this study, Spirit MB-Enlight group could provide successful clinical bonding.

Figure 5 illustrates the load-displacements of the four groups during debonding. Because of creep with the plastic brackets, their load-displacements sloped down slowly after

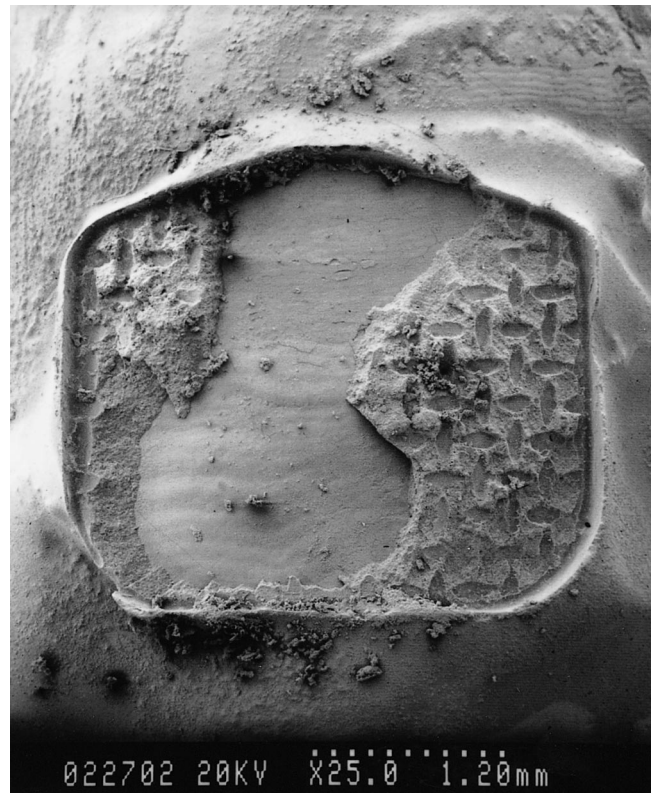


FIGURE 3. SEM (25 \times) shows the enamel surface after debonding in metal bracket—Enlight group. ARI score = 2. No enamel fracture is seen.

the maximum load while those of the metal brackets sloped straight down. Creeping of the plastic brackets could be noted in this study, but metal slot reinforced plastic brackets were clinically capable of torquing teeth sufficiently in two other studies.^{6,7}

The average ARI scores of the metal brackets were lower than those of the plastic brackets for both adhesive groups. The lower ARI scores of the metal brackets may be due to their higher bond strengths. Lower ARI scores mean that the mode of failure is closer to the enamel/adhesive interface and the risk of enamel fracture increases. There were more enamel fractures in the metal groups than in the plastic groups in this study.

Although there was no significant difference in bond strength between the two adhesives in the metal bracket groups, there were five enamel fractures in the System 1+ group and two in the Enlight group. These adhesives have the same difunctional monomer and they are extremely viscous. For practical reasons, they are diluted with another difunctional monomer of much lower viscosity.¹⁹ In clinical use, System 1+ has a higher stickiness than Enlight. The higher stickiness may be the reason for the higher number of enamel fractures. Clinicians should choose suitable adhesives with high bond strengths and a mode of failure close to the bracket/adhesive interface for different types of brackets.

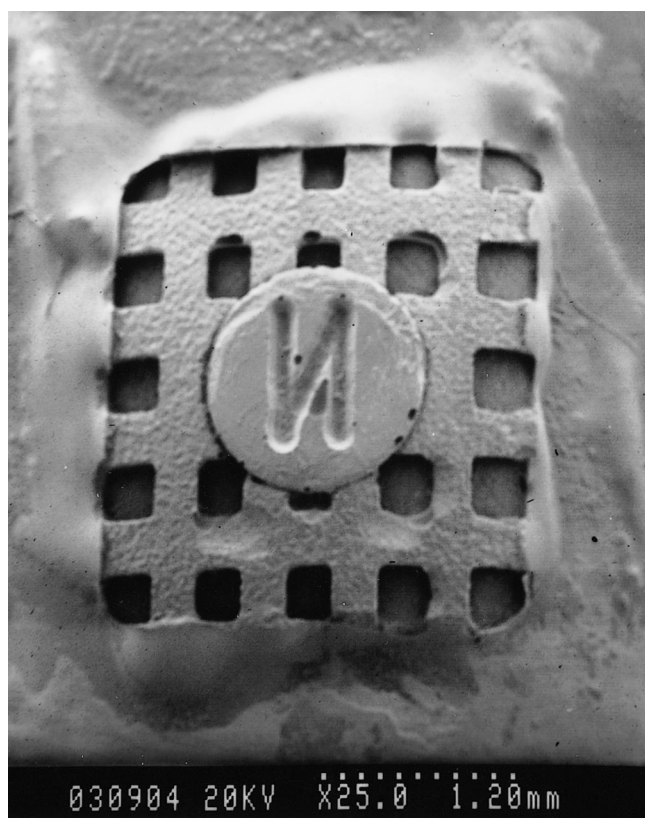


FIGURE 4. SEM (25 \times) shows the enamel surface after debonding in plastic bracket—Enlight group. ARI score = 3. No enamel fracture is seen.

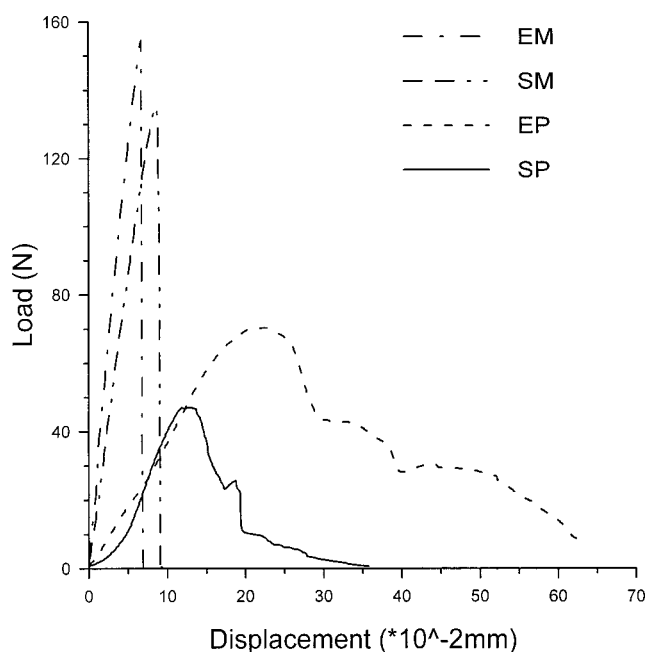


FIGURE 5. The load-displacements of the four groups when debonding. E indicates Enlight; S, System 1+; M, metal; P, plastic; and N, Newton.

CONCLUSIONS

The shear bond strengths of plastic brackets were significantly lower than those of metal brackets ($P < .0001$). There was a statistically significant difference in bond strengths between System 1+ and Enlight for plastic brackets ($P < .05$), but not for metal brackets. The modes of failure were predominantly in the enamel/adhesive interface in metal bracket-System 1+ group, within adhesive in the metal bracket-Enlight and plastic bracket-System 1+ groups, and in the bracket/adhesive interface in the plastic bracket-Enlight group.

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