The Online
ANGLE ORTHODONTIST
An International Journal of Orthodontics and Dentofacial Orthopedics
78th Anniversary 1930-2008

Proudly Sponsored by *The EH Angle Education and Research Foundation*

[Print Version]
[PubMed Citation] [Related Articles in PubMed]

TABLE OF CONTENTS

The Angle Orthodontist: **Vol. 72, No. 2, pp. 141–145.**

Shear Bond Strengths of Plastic Brackets With a Mechanical Base

Jia-Kuang Liu, DDS;[a] Li-Tung Chang, PhD;[b] Shu-Fen Chuang, DDS;[c] Dar-Bin Shieh, DDS, DMSc[d]

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.

KEY WORDS: Polycarbonate brackets, Orthodontic bonding.

Accepted: October 2001. Submitted: July 2001

INTRODUCTION Return to TOC

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 Return to TOC

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 of Ormco 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 mm^2 and 11.07 mm^2 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 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 crosshead 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 (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) scores[12] 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 Return to TOC

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

DISCUSSION Return to TOC

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 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.

CONCLUSIONS Return to TOC

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.

ACKNOWLEDGMENTS

The authors thank Professor Ruey-Mo Lin, Professor Chun-Pin Lin, and Assistant Professor Kuan-Zong Fung for providing facilities and technical help. This study was supported by grant NCKUH-89–084 from National Cheng Kung University Hospital, Tainan, Taiwan.

REFERENCES Return to TOC

1. Sinha PK, Nanda RS. Esthetic orthodontic appliances and bonding concerns for adults. *Dent Clin North Am.* 1997; 41:89–109. [PubMed Citation]

2. Newman GV. Adhesion and orthodontic plastic attachments. *Am J Orthod.* 1969; 56:573–588. [PubMed Citation]

3. Newman GV. First direct bonding in orthodontia. *Am J Orthod Dentofacial Orthop.* 1992; 101:190–191. [PubMed Citation]

4. Aird JC, Durning P. Fracture of polycarbonate edgewise brackets: a clinical and SEM study. *Br J Orthod.* 1987; 14:191–195. [PubMed Citation]

5. Dobrin RJ, Kamel IL, Musich DR. Load-deformation characteristics of polycarbonate orthodontic brackets. *Am J Orthod.* 1975; 67:24–33. [PubMed Citation]

6. Feldner JC, Sarkar NK, Sheridan JJ, Lancaster DM. In vitro torque-deformation characteristics of orthodontic polycarbonate brackets. *Am J Orthod Dentofacial Orthop.* 1994; 106:265–272. [PubMed Citation]

7. Alkire RG, Bagby MD, Gladwin MA, Kim H. Torsional creep of polycarbonate orthodontic brackets. *Dent Mater.* 1997; 13:2–6. [PubMed Citation]

8. Blalock KA, Powers JM. Retention capacity of the bracket bases of new esthetic orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 1995; 107:596–603. [PubMed Citation]

9. Fernandez L, Canut JA. In vitro comparison of the retention capacity of new aesthetic brackets. *Eur J Orthod.* 1999; 21:71–77. [PubMed Citation]

10. Urabe H, Rossouw PE, Titley KC, Yamin C. Combinations of etchants, composite resins, and bracket systems: an important choice in orthodontic bonding procedures. *Angle Orthod.* 1999; 69:267–275. [PubMed Citation]

11. Guan G, Takano-Yamamoto T, Miyamoto M, Hattori T, Ishikawa K, Suzuki K. Shear bond strengths of orthodontic plastic brackets. *Am J Orthod Dentofacial Orthop.* 2000; 117:438–443. [PubMed Citation]

12. Årtun J, Bergland S. Clinical trails with crystal growth conditioning as an alternative to acid-etch pretreatment. *Am J Orthod.* 1984; 85:333–340. [PubMed Citation]

13. Harria AM, Joseph VP, Rossouw PE. Shear peel bond strengths of esthetic orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 1992; 102:215–219. [PubMed Citation]

14. Willems G, Carels CEL, Verbeke G. In vitro peel/shear bond strength evaluation of orthodontic bracket base design. *J Dent.* 1997; 25:271–278. [PubMed Citation]

15. Akin-Nergiz N, Nergiz I, Behlfelt K, Platzer U. Shear bond strength of a new polycarbonate bracket—an in vitro study with 14 adhesives. *Eur J Orthod.* 1996; 18:295–301. [PubMed Citation]

16. Nkenke E, Hirschfelder U, Martus P, Eberhard H. Evaluation of the bond strength of different bracket-bonding systems to bovine enamel. *Eur J Orthod.* 1997; 19:259–270. [PubMed Citation]

17. Reynolds IR, von Fraunhofer JA. Direct bonding in orthodontics: a comparison of attachments. *Br J Orthod.* 1977; 4:65–69. [PubMed Citation]

18. Reynolds IR. A review of direct orthodontic bonding. *Br J Orthod.* 1975; 2:171–178.

19. Sturdevant CM, Roberson TM, Heymann HO, Sturdevant JR. *The Art and Science of Operative Dentistry.* 3rd ed. St Louis, Mo: Mosby-Year Book Inc; 1994:206–287.

TABLES Return to TOC

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

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

[a]MPa 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			SM vs SP / EM vs EP	SP vs EM	SM vs EP	Enamel Fractures
	1	2	3				
SM	6	4	0	*		**	5
SP	2	7	1	*	NS	**	1
EM	2	6	2	*	NS	**	2
EP	0	1	9	*		**	0

[a]ARI 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]Assistant professor, Department of Dentistry, College of Medicine, National Cheng Kung University; Chair, Division of Orthodontics, Department of Dentistry, National Cheng Kung University Hospital

[b]Assistant professor, Department of Childhood Education and Nursery, Chia Nan University of Pharmacy and Science

[c]Attending, Division of Operative Dentistry, Department of Dentistry, National Cheng Kung University Hospital

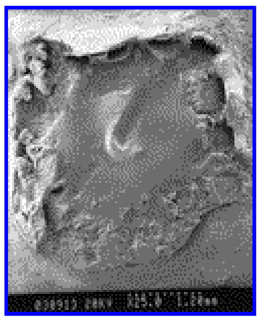
[d]Assistant professor, Department of Dentistry, College of Medicine, National Cheng Kung University; Chair, Division of Oral Diagnosis & Family Dentistry, Department of Dentistry, National Cheng Kung University Hospital

Corresponding author: Dr Jia-Kuang Liu, Department of Dentistry, National Cheng Kung University Hospital, 138 Sheng-Li Road, Tainan 704, Taiwan, ROC (E-mail: jkliu@mail.ncku.edu.tw)

FIGURES Return to TOC

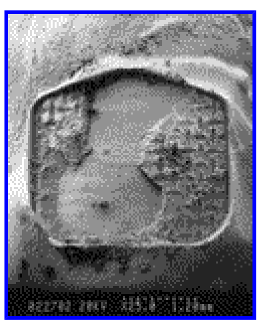
Click on thumbnail for full-sized image.

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



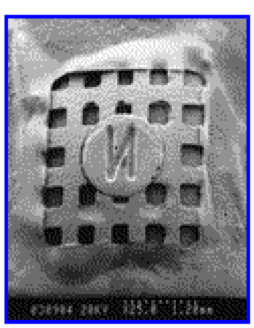
Click on thumbnail for full-sized image.

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



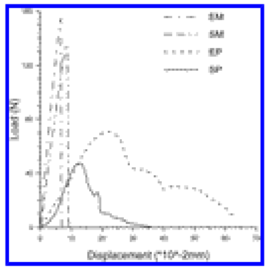
Click on thumbnail for full-sized image.

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



Click on thumbnail for full-sized image.

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



Click on thumbnail for full-sized image.

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

---