

## Original Article

# Metallic Brackets Bonded with Resin-reinforced Glass Ionomer Cements under Different Enamel Conditions

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### ABSTRACT

**Objective:** To assess the shear bond strength of metallic orthodontic brackets bonded with either Fuji Ortho or Ortho Glass LC resin-reinforced glass ionomer cements to enamel surfaces under different conditions, namely, enamel without etching, enamel conditioned with 37% phosphoric acid and enamel conditioned with Transbond Plus Self Etching Primer (TPSEP).

**Materials and Methods:** One hundred and five bovine inferior incisors were divided into seven groups ( $n = 15$ ). In group 1 (control) Transbond XT was used according to the manufacturer's recommendations. In groups 2, 3, and 4 all using Fuji Ortho LC, the brackets were bonded, respectively, to enamel nonetched, enamel etched with 37% phosphoric acid, and enamel etched with TPSEP. In groups 5, 6, and 7, the bonding was performed using Ortho Glass LC under the same enamel conditions observed in the other experimental groups. After 24 hours, shear bond strength tests were performed for all samples at a crosshead speed of 0.5 mm/min.

**Results:** The results (MPa) showed no statistically significant difference between groups 1, 3, and 4 ( $P > .05$ ). However, such groups were statistically superior to the others ( $P < .05$ ). No statistically significant difference was observed between groups 2, 6, and 7 ( $P > .05$ ). Group 5 showed the lowest shear strength value, which was also statistically inferior to the other groups ( $P < .05$ ).

**Conclusions:** Regardless of the enamel treatment, Fuji Ortho LC yielded shear strength values superior to those from Ortho Glass LC. (*Angle Orthod* 2006;76:700–704.)

**KEY WORDS:** Glass ionomer cement; Shear strength; Dental bonding; Orthodontic brackets

### INTRODUCTION

In orthodontics, the white spot lesions and marginal gingivitis worry most practitioners; as a result, they are well aware of the new materials for minimizing and

preventing such lesions. Among these materials, the glass ionomer cement stands out from all the others. Developed by Wilson and Kent,<sup>1</sup> the glass ionomer cement allows chemical adhesion to enamel, dentin, and other surfaces and releases fluoride.<sup>2–4</sup>

The evolution in glass ionomer cements has contributed to the reduction in dental caries in orthodontic patients because of the biological and chemical characteristics of this material.<sup>5</sup> However, despite the favorable characteristics of such materials, the brackets do not provide adequate retention to the enamel, sometimes resulting in insufficient bond strength.<sup>6–13</sup>

In recent years, the manufacturers of such materials have developed new glass ionomer cements incorporating a resin matrix to minimize this problem. As a result, both the resin's retentive capacity and other ionomer properties could be allied. Such materials are commonly called resin-reinforced glass ionomer cements.

Some authors<sup>14,15</sup> have demonstrated the efficacy of these glass ionomer cements for bonding brackets to

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dried nonconditioned enamel. Other tests have demonstrated sufficient bond strength when these materials are applied onto contaminated and moistened surfaces. Indeed, the adhesion, in some cases, has been found to be superior to other materials.<sup>14,16-21</sup>

Enamel conditioning using phosphoric acid or acid primer before bonding the brackets with resin-reinforced glass ionomer cement has demonstrated adequate adhesive results. In fact, some studies have found values close to or higher than those from nonconditioned surfaces.<sup>17,22-24</sup>

The aim of this study was to assess the shear bond strength of metallic brackets bonded with either Fuji Ortho LC (GC America Corp, Tokyo, Japan) or Ortho Glass LC resin-reinforced glass ionomer cements (DFL, Rio de Janeiro, Brazil) to nonconditioned enamel, enamel conditioned with 37% phosphoric acid, and enamel conditioned with Transbond Plus Self Etching Primer (TPSEP) (3M Unitek, Monrovia, Calif).

## MATERIALS AND METHODS

A total of 105 bovine mandibular incisors were used in this *in vitro* study. They were cleansed, stored in 10% formaldehyde solution, and kept refrigerated at approximately 6°C.

A special gypsum stone (Durone, Dentsply, Petrópolis, Brazil) was used for embedding the teeth in polyvinyl chloride-rigid rings (Tigre, Joinville, Brazil) so that only their crowns were exposed. The buccal surfaces of these crowns were perpendicularly positioned in relation to the shearing die's base by using a glass square placed at an angle of 90° to enable the mechanical test. After the gypsum crystallization, all the sample sets were stored in distilled water and placed again in the refrigerator.

Before bonding the brackets, the buccal surfaces of all the teeth were cleaned with rubber cups (Viking KG Sorensen, Barueri, Brazil), using nonfluoridated pumice (SS White, Juiz de Fora, Brazil) and water for 15 seconds. Next, the samples were washed with air-water spray for 15 seconds and air-dried for the same period of time using an air-syringe free of oil and humidity. The rubber cup was replaced after every five prophylaxis treatments.

The samples were randomly divided into seven groups ( $n = 15$ ), namely, group 1 (Control), brackets bonded with Transbond XT composite (3M Unitek); groups 2, 3, and 4, brackets bonded with Fuji Ortho LC resin-reinforced glass ionomer cement (GC America Corp); and groups 5, 6, and 7, brackets bonded with Ortho Glass LC resin-reinforced glass ionomer cement (DFL), as follows.

Group 1: enamel conditioned with 37% phosphoric acid (3M Dental Products, Monrovia, Calif) for 15

seconds, cleansed, dried for the same period of time, XT primer applied, and brackets bonded with Transbond XT.

Group 2: enamel not conditioned and brackets bonded with Fuji Ortho LC cement.

Group 3: enamel conditioned with 37% phosphoric acid (3M Dental Products) for 15 seconds, washed, and dried for the same period of time. Brackets were bonded with Fuji Ortho LC cement.

Group 4: enamel conditioned with TPSEP (3M Unitek) by rubbing the material on the surface for three seconds. An air-dried jet was slightly applied to the enamel, and the brackets were bonded with Fuji Ortho LC cement.

Group 5: enamel not conditioned and brackets were bonded with Ortho Glass LC cement.

Group 6: enamel conditioned with 37% phosphoric acid for 15 seconds (3M Dental Products) and washed and dried for the same period of time. Brackets were bonded with Ortho Glass LC cement.

Group 7: enamel conditioned with TPSEP by rubbing the material on the surface for three seconds. An air-dried jet was slightly applied to the enamel and brackets were bonded with Ortho Glass LC cement.

Orthodontic central incisor brackets with a base surface area of 13.8 mm<sup>2</sup> were used for all teeth (Abzil Lancer, São José do Rio Preto, Brazil). The same operator performed all the bonding procedures. All the samples were light cured for 40 seconds (10 seconds for each face—mesial, distal, incisive border, and gingival) at a one mm distance from the bracket using a Light Curing 2500 (3M Dental Products) with a light intensity of 550 mW/cm<sup>2</sup>. The intensity light was calibrated for each polymerization using a radiometer (Demetron, Danbury, Conn).

After the bonding procedure, the samples were stored in distilled water for 24 hours at a constant temperature of 37°C. The shear strength test was performed by using a chisel-edge mounted in the crosshead of the universal testing machine (Instron Corporation, Canton) operating at a crosshead speed of 0.5 mm/min.

A stereoscopic magnifying glass (Carl Zeiss, Goettingen, Germany) with a magnification of 8× was used for evaluating the buccal surface of each sample. According to the criteria determined by Årtun and Bergland,<sup>25</sup> the adhesive remnant index (ARI) is quantified as follows: 0 = no adhesive remaining; 1 = less than half of adhesive remaining; 2 = more than half of adhesive remaining; 3 = all adhesive remaining.

The results of the shear bond strength tests were submitted to analysis of variance in 2 × 3 factorial

**Table 1.** Mean Shear Bond Strength Values and Statistical Analysis<sup>a</sup>

Groups	Mean (MPa)	Statistical Analysis
1	11.37 (2.53)	A
2	2.84 (1.18)	B
3	11.94 (2.00)	A
4	9.54 (2.00)	A
5	1.68 (0.77)	C
6	4.29 (1.34)	B
7	5.26 (1.18)	B

<sup>a</sup> Equal letters = absence of statistically significant difference ( $P > .05$ ).

**Table 2.** ARI Scores and Mean Values Presented by Group<sup>a,b</sup>

Groups	ARI Scores			
	0	1	2	3
1	3	4	3	5
2	11	4	0	0
3	0	1	7	7
4	0	1	10	4
5	8	7	0	0
6	2	6	6	1
7	0	2	9	4

<sup>a</sup> 0, no adhesive remaining; 1, less than half of adhesive remaining; 2, more than half of adhesive remaining; 3, all adhesive remaining.

<sup>b</sup> ARI indicates adhesive remnant index.

schema (material  $\times$  condition) with a control treatment. The Tukey's test was used for comparing the factors, whereas the Dunnett's test was used for verifying the control involving other treatments (5% significance). The ARI scores were assessed by using the Kruskal-Wallis test.

## RESULTS

There was no statistically significant difference in the shear bond strength values ( $P > .05$ ) between group 1 (Transbond XT), group 3 (Fuji Ortho LC cement on enamel etched with 37% phosphoric acid), and group 4 (Fuji Ortho LC cement on enamel etched with TPSEP) (Table 1). These groups, however, were statistically superior to the other groups ( $P < .05$ ).

No statistically significant difference was observed between group 2 (Fuji Ortho LC cement on enamel nonconditioned), group 6 (Ortho Glass LC cement on enamel etched with 37% phosphoric acid), and group 7 (Ortho Glass LC cement on enamel etched with TPSEP) ( $P > .05$ ). Group 5 (Ortho Glass LC cement on enamel nonconditioned) showed the smallest shear bond strength value, thus being considered statistically inferior to the other groups ( $P < .05$ ).

In the evaluation of the ARI, the scores within each group are shown in Table 2. There was no statistically significant difference between groups 1 and 3 ( $P =$

.0635), groups 1 and 4 ( $P = .1764$ ), groups 1 and 6 ( $P = .4812$ ), groups 2 and 5 ( $P = .6595$ ), groups 3 and 4 ( $P = .6146$ ), groups 3 and 7 ( $P = .4943$ ), groups 4 and 7 ( $P = .8573$ ), and groups 6 and 7 ( $P = .0606$ ).

However, a statistically significant difference was present between groups 1 and 2 ( $P = .0006$ ), groups 1 and 5 ( $P = .0026$ ), groups 2 and 3 ( $P = .0000$ ), groups 2 and 4 ( $P = .0000$ ), groups 2 and 6 ( $P = .0060$ ), groups 2 and 7 ( $P = .0000$ ), groups 3 and 5 ( $P = .0000$ ), groups 3 and 6 ( $P = .0015$ ), groups 4 and 5 ( $P = .0000$ ), groups 4 and 6 ( $P = .0398$ ), groups 5 and 6 ( $P = .0210$ ), and groups 5 and 7 ( $P = .0000$ ).

## DISCUSSION

The composite is one of the most used bonding materials in orthodontics over the years.<sup>2</sup> The glass ionomer cements were developed in an effort to aggregate the adhesive characteristics as well as the biological and chemical properties into one material. Such cements not only provide enamel bonding but also have a mechanism for releasing and reloading fluoride so that the white spot lesions around the orthodontic brackets and bands can be reduced. In addition, this material facilitates the debonding procedures without injuring the enamel surface.<sup>1-5</sup>

In this study, there was no statistical significance in the shear bond strength values between group 1 (Transbond XT, control), group 3 (Fuji Ortho LC cement on enamel conditioned with 37% phosphoric acid), and group 4 (Fuji Ortho LC cement on enamel conditioned with TPSEP). Although some studies do not agree with these findings,<sup>7,8,11-13</sup> this study suggests that Fuji Ortho LC can be clinically applied to conditioned enamel, thus corroborating findings by others authors.<sup>7,23,24</sup>

Group 2 (Fuji Ortho LC cement on enamel nonconditioned) and group 5 (Ortho Glass LC cement on enamel nonconditioned) had the lowest shear bond strength values, the latter being statistically inferior to the other groups. The low adhesive values of these groups, whose enamel had not been conditioned, can be explained by the lack of mechanical retention between material and tooth and a bond that likely occurred by chemical adhesion only.<sup>6-8,11-13</sup> The results presented by groups 2 and 5 were not similar to the results presented by the other groups.<sup>14,15</sup>

To decrease the number of conventional bonding procedures and to make this technique faster, a new system combining primer and acid into one solution was developed, the Self Etching Primer. Although this study was not aimed at evaluating the bonding time spent in each type of system, such procedures were simplified when TPSEP was used.

Group 4 (Fuji Ortho LC cement on enamel condi-

tioned with TPSEP) and group 7 (Ortho Glass LC cement on enamel conditioned with TPSEP) had statistically significant differences when compared with each other. The use of Fuji Ortho LC cement showed higher shear bond strength than Ortho Glass LC cement, probably because of the improved chemical characteristics presented by the former, which allowed a better adhesion to the enamel. Cacciafesta et al<sup>24</sup> evaluated the bonding procedure of Fuji Ortho LC cement under the same conditions used for group 4 in this study. They also found the shear bond strength of this material suitable, thus making feasible the use of this glass ionomer material in conjunction with TPSEP.

In groups 3 and 6, the enamel samples were conditioned with 37% phosphoric acid and the brackets were bonded with Fuji Ortho LC and Ortho Glass LC cements, respectively. Group 3 presented higher values for the shear bond strength in comparison with group 6. Considering that both groups used the same type of enamel conditioning, this suggests that such chemical differences between these materials reflected the increased adhesiveness with Fuji Ortho LC.

The ARI analysis revealed a statistical superiority for groups 1, 3, 4, and 7 because there was no statistically significant difference between them. Such superiority is due to the fact that these groups had their enamel samples conditioned with 37% phosphoric acid or TPSEP, thus resulting in both chemical and mechanical association between material and tooth. Although group 6 presented inferior ARI values even using phosphoric acid conditioning, Fuji Ortho LC and Ortho Glass LC cements showed differences using this same type of surface treatment. Such a statistical superiority, which is similar to the results for shear bond strength, shows that the groups presenting greater ARI values, on average, also have greater adhesiveness values.

Groups 1, 3, 4, 6, and 7 presented the majority of fractures at the bracket-composite interface, although some adhesive material could be observed following the debonding. On the other hand, groups 2 and 5 presented the majority of fractures in the enamel-composite interface, which was predominantly expressed by ARI scores of zero (no adhesive remaining). The values presented by both groups corroborate the majority of studies existing in the literature.<sup>12,23,24</sup>

## CONCLUSIONS

- Both conventional Transbond XT and Fuji Ortho LC cements presented satisfactory shear bond strength results for brackets bonded to enamel surface conditioned with 37% phosphoric acid or TPSEP.
- Both glass ionomer cements, Fuji Ortho LC and Or-

tho Glass LC, presented low adhesiveness values for nonconditioned enamel.

- Regardless of the type of enamel surface, the mean shear bond strength values obtained by Fuji Ortho LC cement were superior to those obtained by Ortho Glass LC cement.
- For those groups presenting greater strength bond values, the majority of fractures occurred in the interface between bracket-composite.

## REFERENCES

1. Wilson AD, Kent BE. The glass ionomer cement: a new translucent filling material. *J Appl Chem Biotechnol.* 1971; 21:313.
2. Silverman E, Cohen M, Denke RS, Silverman M. A new light-cured glass ionomer cement that bonds brackets to teeth without etching in the presence of saliva. *Am J Orthod Dentofacial Orthop.* 1995;108:231–236.
3. Freitas PC. Glass ionomer cement as an alternative in orthodontic bonding. *Ortodontia.* 1998;32:42–47.
4. Pascotto RC. Orthodontic bonding agents. Part I—glass ionomer cements. *R Dental Press Ortodon Ortop Facial.* 2001;6:109–116.
5. McCarthy MF, Hondrum SO. Mechanical and bond strength properties of light-cured and chemically cured glass ionomer cements. *Am J Orthod Dentofacial Orthop.* 1994;105: 135–141.
6. Cook PA. Direct bonding with glass ionomer cement. *J Clin Orthod.* 1990;24:509–511.
7. Miguel JAM, Almeida MA, Chevitaese O. Clinical comparison between a glass ionomer cement and a composite for direct bonding of orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 1995;107:484–487.
8. Lippitz S, Staley RN, Jakobsen JR. In vitro study of 24 hour and 30 day shear bond strengths of three resin-glass ionomer cements used to bond orthodontics brackets. *Am J Orthod Dentofacial Orthop.* 1998;113:620–624.
9. Orthendhal T, Thilander B. Use of glass-ionomer for bracket bonding—an ex vivo study evaluating a testing device for in vivo purposes. *Eur J Orthod.* 1998;20:201–208.
10. Myaki SI, Fava M, Hayashi PM, Ursi WJS. Adhesion of orthodontic buttons to primary teeth enamel using resin composite or resin-modified glass ionomer cement. *J Bras Ortodon Ortop Facial.* 1998;3:19–25.
11. Silva Filho OG, Oliveira CBA, Fontes MV, Ozawa TO. Clinical evaluation of a light-cured glass ionomer cement (Vitre-bond) for direct bonding of orthodontic brackets in 4 × 2 leveling. *R Dental Press Ortodon Ortop Facial.* 1999;4:31–44.
12. Bishara SE, VonWald LBA, Olsen ME, Laffoon JF. Effect of time on the shear bond strength of glass ionomer and composite orthodontic adhesives. *Am J Orthod Dentofacial Orthop.* 1999;116:616–620.
13. Souza CS, Francisconi PAS, Araújo PA. Bond strength of five cements for orthodontics use. *Rev FOB.* 1999;7:15–21.
14. Cacciafesta V, Jost-Brinkman PG, Sußenger U, Miethke RR. Effects of saliva and water contamination on the enamel shear bond strength of a light-cured glass ionomer cement. *Am J Orthod Dentofacial Orthop.* 1998;113:402–407.
15. Romano FL, Ruellas ACO. Comparative study of materials used for cementation of orthodontic bands. *J Bras Ortodon Ortop Facial.* 2002;6:494–499.
16. Jobalia SB, Valente RM, Rijk WG, BeGole EA, Evans CA.



- Bond strength of visible light-cured glass ionomer orthodontic cement. *Am J Orthod Dentofacial Orthop.* 1997;112:205–208.
17. Bishara SE, Olsen ME, Damon P, Jakobsen JR. Evaluation of a new light-cured orthodontic bonding adhesive. *Am J Orthod Dentofacial Orthop.* 1998;114:80–87.
  18. Araújo MTS, Campista C, Chevitarese O, Guimarães JP, Ruela ACO. Contaminação de saliva humana na colagem de cimento de ionômero de vidro e compósito em esmalte bovino: resistência ao cisalhamento. *R Bras Odont.* 1998; 55:45–47.
  19. Itoh T, Matsuo N, Fukushima T, et al. Effect of contamination and etching on enamel bond strength of new light-cured glass ionomer cements. *Angle Orthod.* 1999;69:450–456.
  20. Chung C, Cuzzo PT, Mante FK. Shear bond strength of a resin-reinforced glass ionomer cement. An in vitro comparative study. *Am J Orthod Dentofacial Orthop.* 1999;115:52–54.
  21. Valente RM, Rijk WG, Drummond JL, Evans CA. Etching conditions for resin-modified glass ionomer cement for orthodontic brackets. *Am J Orthod Dentofacial Orthop.* 2002; 121:516–520.
  22. Campista C, Chevitarese O, Bolognese AM, Lage SA. Bonding of metallic brackets in buccal cervical region of inferior premolars with Fuji Ortho LC. *J Bras Ortodon Ortop Facial.* 1997;2:17–20.
  23. Meehan MP, Foley TF, Mamandras AH. A comparison of the shear bond strengths of two glass ionomer cements. *Am J Orthod Dentofacial Orthop.* 1999;115:125–132.
  24. Cacciafesta V, Sfondrini MF, Baluga L, Scribante A, Klersy C. Use of a self-etching primer in combination with a resin-modified glass ionomer: effect of water and saliva contamination on shear bond strength. *Am J Orthod Dentofacial Orthop.* 2003;124:420–426.
  25. Årtun J, Bergland S. Clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment. *Am J Orthod.* 1984;85:333–340.