

A clinical study of glass ionomer cement

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SUMMARY The aim of this investigation was to compare the clinical performance of a glass ionomer cement (GIC) with a composite resin when used for direct bonding of standard edgewise orthodontic brackets. Fourteen patients (10 females, four males), in whom 242 teeth were bonded with brackets, were divided into two groups: GIC (121 teeth) and composite (121 teeth). The brackets were allocated to alternate quadrants and first-time failures were recorded over a period of 24 months. Data were analysed statistically (non-parametric chi-squared test).

The results demonstrated a significantly lower unpreviewed debonding index (UDI) (15.7 per cent) for the composite than for the GIC (28.1 per cent) ($P = 0.042$). The use of heavy archwires was largely responsible for this difference. No difference was observed when light and medium archwires were used. GIC may be a viable alternative to composite for use with light archwires and with limited treatment objectives.

Introduction

Clinical comparisons of several glass ionomer cements (GIC) with traditional composite for the bonding of orthodontic brackets have not shown sufficiently favourable results to recommend the routine use of GIC. However, with the advent of hybrid GIC (resin reinforced), Millet and McCabe (1996) found improved resistance to traction and shearing forces.

Silverman *et al.* (1995), using Nitinol wires for levelling, investigated a hybrid GIC, Fuji Ortho LC, clinically recording the first-time failures during an observation period of 8 months. The results showed an unpreviewed debonding index (UDI) of 3.2 per cent. This compared well with the performance of composites (Millet and McCabe, 1996). Silverman *et al.* (1997) described the disadvantages of this cement as the long setting time and incomplete polymerization from poor access of the curing light. In an effort to overcome this problem, Fuji Ortho developed a hybrid GIC with the same chemical and physical properties as Fuji Ortho LC, but the former was chemically activated (self-curing) and showed two advantages: (1) a shorter setting time; (2) more complete polymerization. Silverman *et al.* (1997) evaluated this new GIC in a similar study to their previous investigation. The UDI was 3.3 per cent when bonding was carried out without enamel conditioning or moisture control, initially using 0.016 inch Nitinol wires.

The bonding technique developed by Fricker (1998) comprised prophylaxis, washing with water and rapid drying of the enamel. Dentine conditioning was then immediately applied for 10 seconds, and drying was repeated. The arches were placed 20 minutes after bonding. Twenty wires were used: 14 of which were 0.014 inch

stainless steel, four 0.012 inch stainless steel and two nickel–titanium (Nitinol), and observed for 12 months. The results showed a UDI of 5.0 per cent for GIC (three unpreviewed debondings). According to these results, the author concluded that Fuji Ortho was a satisfactory adhesive for use in direct bonding of orthodontic brackets, when there are no occlusal interferences.

The aim of this investigation was to compare the clinical performance of a GIC (Fuji Ortho LC) with a composite resin (Concise) when used for direct bonding of standard edgewise orthodontic brackets.

Subjects and method

The sample comprised 14 patients (10 females and four males), selected from the Orthodontic Department, University of Rio de Janeiro State, Brazil. The patients' ages varied from 10 to 15 years. The selection of patients did not follow any criterion related to sex, age, ethnicity or type of malocclusion. All had parental consent to participate in the study, which was approved by the Ethics Committee on Human and Animal Research of the University of Rio de Janeiro State. All received standard edgewise appliances.

The teeth used in the study were the central and lateral incisors, canines and first and second premolars in both arches. In total, 242 teeth were used, divided into two groups: 121 teeth bonded with Concise (3M do Brasil Ltd, Sumaré SP, Brazil) and 121 teeth bonded with Fuji Ortho LC (GC Corporation, Tokyo, Japan).

Metal brackets (American Orthodontics, Sheboygan, Wisconsin, USA) were used with a 0.022×0.028 inch slot. Following the specific indication for each tooth, the

curing light (Unitek: Ortholux XT, Monrovia, California, USA) had a wavelength of 730 nm. The two bonding materials were used in a split mouth design, inverting the quadrants, in each patient (Figure 1).

The bonding technique with Concise followed the manufacturer's instructions. Bonding with GIC was performed without enamel etching or drying, to maintain enamel integrity, according to the manufacturer's instructions and the recommendations of Silverman *et al.* (1995):

1. Prophylaxis with pumice and water on the vestibular surfaces of the teeth, isolation with retractors and suction.
2. Washing with water.
3. The powder (one portion of the measure) was incorporated with the liquid (two drops), using a metallic spatula. At this stage, the acid-base reaction was commenced.
4. Placement of the material on the base of the bracket.
5. Placement of the bracket on the dental surface, with light pressure, aiming to achieve the smallest thickness of the material.
6. Removal of the excess cement with a dental explorer.
7. Polymerization with the curing light, for 15 seconds at the occlusal, gingival, mesial and distal sides.

Regarding the proportion of powder/liquid of the GIC, the manufacturer indicates that one portion is sufficient for bonding five brackets with the same mix, before

setting. However, in practice, each mix did not allow time to bond more than one bracket at a time.

Bond failure rates were also investigated during different archwire stages: light (0.0175 inch, twist flex, and 0.014 inch stainless steel) with high resilience and low modulus of elasticity, used during the initial stage of therapy; medium (0.016 and 0.018 inch stainless steel) with medium resilience and modulus of elasticity, used in the intermediate stage of therapy; heavy (0.020 and 0.019 × 0.025 inch stainless steel) with low resilience and high modulus of elasticity, used in the final stage of therapy. The twist flex and stainless steel wires were obtained from Dental Morelli (Sorocaba, SP, Brazil).

The patients were observed for 24 months, the average period of orthodontic treatment, during which time the UDI was recorded for later analysis.

When bracket failures occurred, new brackets were bonded with the same type of material using its specific bonding technique. However, the brackets were not included in the study analysis, as the aim was to evaluate first-time failures only.

In order to verify if a difference exists between the rates of UDI of the two materials, the non-parametric chi-squared test was used. Statistically significant differences were considered between the tested materials at the 5 per cent level.

Results

Bracket failures and the results of the statistical analysis of both materials in relation to the total number of tested teeth are shown in Table 1 and Figure 2.

For the total tooth sample there was a significant difference ($P = 0.042$) between the GIC and the composite UDIs. The GIC showed a UDI of 28.1 per cent, and the composite a UDI of 15.7 per cent (a 79 per cent increase).

The results of different archwire stages are shown in Table 2 and Figure 3. There were statistically significant differences ($P = 0.019$) between the materials, using the heavy wires only. The UDI was 17.4 per cent for the GIC and 7.4 per cent for the composite. This was an increase of 135 per cent. No significant differences were found in bond failure rates when light and medium archwires were used.

Discussion

Since the first investigation of White (1986), further studies have been undertaken (Table 3). In all of them it is important to note: (1) the GIC tested; (2) the sample number; (3) the time of observation; (4) the number of UDIs (main item); (5) the enamel preparation; (6) the types of wire used. The purpose of the present research was to compare the UDIs of brackets bonded with Fuji Ortho LC with Concise in patients under orthodontic

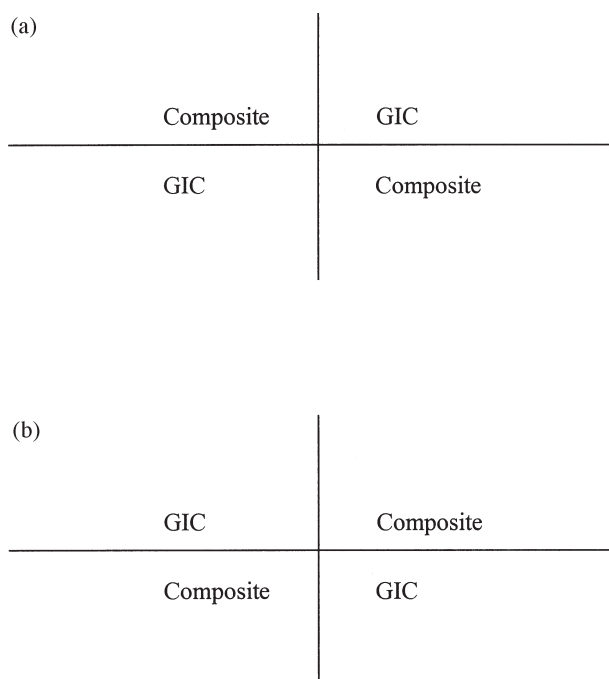
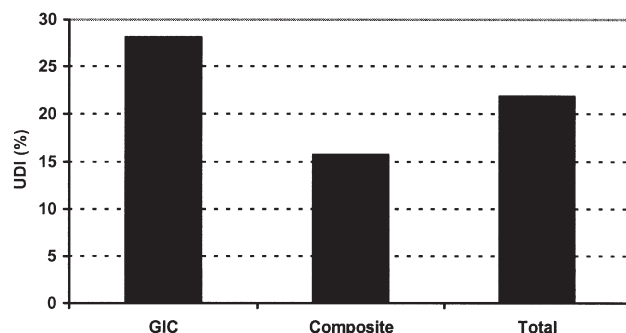


Figure 1 The split mouth design demonstrating the quadrants in which the bracket adhesive was used.

Table 1 Comparison of bracket failure rates of glass ionomer cement and composite for the total sample.

Material	Tested teeth	Unpreviewed debondings	UDI (%)	P value
Glass ionomer cement	121	34	28.1	0.042
Composite	121	19	15.7	
Total	242	53	21.9	

UDI, unpreviewed debonding index.

**Figure 2** Comparison of bracket failure rates of glass ionomer cement (GIC) and composite for the total sample.

therapy in relation to the total sample and the types of wire used. The frequency of first-time bond failures (UDI) is the most commonly used method of investigation.

Comparing the present investigation with the results of studies over the last 12 years (Table 3), it was noted that not only the type of GIC influenced the achieved results (UDIs), but also the methods used (enamel preparation, number of bonded brackets, observation time and types of arch).

In the present study, the UDI was greater than that reported in the literature when the conventional type of GIC was analysed, except for the experiments of Miguel *et al.* (1995), Miller *et al.* (1996) and Norevall *et al.* (1996). In those studies, bonding was carried out with

acid conditioning (unlike the present investigation, where GIC was used without acid conditioning), and showed the hybrid GIC to have higher resistance to failure.

Silverman *et al.* (1995) reported a UDI of 3.2 per cent using the same cement. This result may be explained by the type of wire used (Nitinol wires, in all cases, but not medium and heavy arches). In the present study, light, medium and heavy steel arches were used over a longer observation period (24 months) (Table 3). The heavy wires were responsible for the greatest difference between the UDIs of both materials; the GIC showed a UDI of 17.4 per cent and the composite 7.4 per cent. This was 135 per cent more GIC first-time failures in comparison with the composite, a statistically significant difference ($P = 0.019$), but no statistical difference was observed between the GIC and the composite in the light and medium wire stages. This can be explained by the greater shearing forces applied by the heavy wires, mainly the 0.019×0.025 inch arch in the production of apical movements. According to Quintão and Chevitarrese (1989), solid stainless steel arches produce greater orthodontic forces than Nitinol, and, as a result, a greater probability of bond failures. In addition, stainless steel wires are more frequently used than Nitinol arches in orthodontic therapy. This same consideration is also valid when the results of the present study are compared with those of Fricker (1994, 1998) and Silverman *et al.* (1997), as those authors also used stainless steel light wires and/or Nitinol wires (Table 3).

Table 2 Comparison of bracket failure rates of glass ionomer cement (GIC) and composite for the different archwire types.

Wires	Tested teeth	Unpreviewed debondings	UDI (%)	P value
Light				
GIC	121	7	5.8	1.0
Composite	121	7	5.8	
Medium				
GIC	121	6	5.0	0.308
Composite	121	3	2.5	
Heavy				
GIC	121	21	17.4	0.019
Composite	121	9	7.4	

UDI, unpreviewed debonding index.

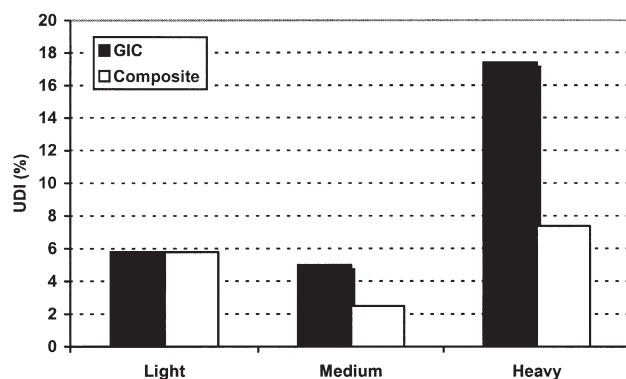


Figure 3 Comparison of bracket failure rates of glass ionomer cement (GIC) and composite for the light, medium and heavy arches.

An important consideration in the present study was that every type of wire was used for at least 2 weeks, and that during the first days the brackets were more vulnerable to debonding. In addition, the patients were chosen at random, and did not follow any pattern of dental or skeletal malocclusion. Nevertheless, it was thought necessary and important to evaluate the types of wire involved during each therapy, based on each wire's thickness, on its resilience and elasticity, and, consequently, on its strength, according to Quintão and Chevitarese (1989).

Another interesting finding was the great wastage of cement (about 80 per cent of the mixture) in each portion used. The manufacturer indicates that the bonding of four to five brackets is possible with each portion, but this goal was not achieved. Only one bracket could be bonded with each mixture due to the

fast initial acid–base reaction. It is, therefore, suggested that the proportion of powder to liquid for this cement should be decreased to increase working time and to reduce wastage. In addition, heavy archwires (0.020 and 0.019 × 0.025 inch diameter) should be avoided to reduce clinical bond failures. Furthermore, GIC may be a viable alternative to composite for use with light archwires and with limited treatment objectives.

Conclusions

Based on the results, it can be concluded that:

1. Bonding with GIC resulted in significantly more first-time bracket failures ($P = 0.042$) when compared with composite.
2. The use of heavy archwires was largely responsible for this difference ($P = 0.019$ in heavy wires), whereas no difference was seen when using light and medium wires.

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Table 3 Previous clinical trials of glass ionomer cement (GIC) (C: conventional or H: hybrid) unpreviewed debonding index (UDI).

Clinical trial	GIC	Type of GIC	Enamel conditioning	Number of bonded brackets	Observation period (months)	Wires used	UDI (%)
Miller <i>et al.</i> (1989)	Ketac-fil	C	–	53	2.2	–	3.8
Cook (1990)	Ketac-cem	C	–	402	17.1	–	12.4
Lodter and Sarda (1991)	Ketac-bond	C	–	42	6.0	–	13.0
Lodter and Sarda (1991)	Ketac-fil	C	–	37	6.0	–	4.4
Fricker (1992)	Fuji I	C	Poly (acrylic acid)	60	12.0	Light	20.0
Millett (1992)	Ketac-cem	C	Without	120	12.0	–	17.0
Miguel <i>et al.</i> (1995)	Ketac-cem	C	37% phosphoric acid	112	12.0	–	50.9
Miller <i>et al.</i> (1996)	Ketac-fil	C	Poly (acrylic acid)	162	31.0	–	33.0
Norevall <i>et al.</i> (1996)	Aqua-cem	C	37% phosphoric acid	479	21.0	–	36.0
Fricker (1994)	Fuji II LC	H	Poly (acrylic acid)	60	12.0	Light	3.3
Silverman <i>et al.</i> (1995)	Fuji Ortho LC	H	Without	3226	8.0	Nitinol	3.2
Silverman <i>et al.</i> (1997)	Fuji Ortho	H	Without	7268	12.0	Nitinol	
Fricker (1998)	Fuji Ortho	H	Without	60	12.0	Nitinol (0.016 inch)	3.3
						Nitinol (0.014 inch)	
						stainless steel (0.012 and 0.014 inch)	5.0

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