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An *ex vivo* assessment of resin-modified glass ionomer bonding systems in relation to ceramic bracket debond

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Abstract. *This* ex vivo *study assessed three new resin-modified glass ionomer cements (Fuji ORTHO LC™, Vitremer™, and Dyract-Cem™) in relation to ceramic bracket removal. It was hypothesized that the use of these cements would facilitate bracket removal and eliminate debond complications*

Eighty extracted premolar teeth were divided into four groups of 20 teeth and bonded with Intrigue™ brackets using each of the resin-modified cements (groups 1, 2, and 3), the control group 4 was bonded with Concise™ chemically-cured adhesive. The teeth were debonded by applying a shear load using an Instron universal testing machine. The mean force to debond was calculated for each group and each tooth was examined under the stereomicroscope to record the site of bond failure and the Adhesive Remnant Index (ARI).

The results showed that the resin-modified cements were very effective at eliminating ceramic bracket debond problems. Bracket fracture was eliminated compared with a 40 per cent fracture rate with the control and the ARI scores were all reduced. The elimination of debond problems appears to be related to the significantly reduced ($P < 0.001$ using ANOVA and Tukey tests) mean and maximal debond forces compared with the control.

Index words: Ceramic bracket debond, Glass ionomer, Resin modified.

Introduction

The use of glass ionmer cements in orthodontic bracket bonding has, to date, been of only limited success. They have the advantage of bonding directly to tooth tissue and a cariostatic action due to their fluoride leaching ability (Valk and Davidson, 1987; Hallgren *et al*., 1990). Their use in orthodontic bonding has been limited, however, due to inferior mechanical properties, in particular bond strength (Fricker, 1992).

However, studies suggest that the new generation of resin-modified glass ionomer cements have improved properties including bond strength (Cook and Youngson, 1989; Chan *et al*., 1990; Rezk-Lega and Ogaard, 1991; Compton *et al*., 1992; McCarthy and Hondrum, 1994). Other studies have reported clinically acceptable failure rates with these cements in clinical trials (Fricker, 1994; Silverman *et al*., 1995).

No previous studies have assessed the use of resin-modified cements in relation to ceramic brackets. When used with metal brackets it has been observed that, on bracket removal, bond failure tends to occur at the enamel/resin interface with no retained resin on the enamel surface. From a debond perspective, this would be an advantage as less clinical time would have to be spent removing residual resin, thereby reducing the risk of enamel damage and patient discomfort. In addition, the altered site of bond failure may help eliminate other ceramic bracket debond problems such as bracket fracture.

This study aimed to assess *in vitro* the debond behaviour of ceramic brackets when bonded with resin-modified glass ionomer cements. It was hypothesized that the use of these cements would facilitate bracket removal and eliminate debond complications.

Materials and Methods

Eighty sound extracted premolar teeth extracted for orthodontic purposes from patients under the age of 18 years were collected and stored in 0·5 per cent Chloramine T disinfectant solution. Prior to testing, the teeth were stored for a 2-week period in distilled water in the refrigerator.

The teeth were divided randomly into four groups of 20 teeth, each consisting of 10 maxillary and 10 mandibular premolars. The roots were then notched using a 'rosehead' bur in a contra-angle handpiece to aid retention prior to mounting in polyester blocks with the long axis of each tooth vertical.

The teeth were bonded with Intrigue™ ceramic brackets using the following bonding systems:

Group 1: Dyract-Cem™ (Dentsply Ltd, Surrey, UK)
Group 2: Vitremer™ (3M, St Paul, Mn, USA)
Group 3: Fuji ORTHO LC™ (GC Corp. Tokyo, Japan).
Group 4: Orthodontic Concise™ (3M,St.Paul, Mn, USA)

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In accordance with the manufacturers recommendations the enamel surfaces of the resin-modified cements (groups 1, 2, and 3) were not etched and with the Fuji ORTHO LC™ the enamel surfaces were not dried prior to bonding. In the conventional composite control group 4, the enamel surfaces were etched and bonded as normal.

All the materials were mixed and applied according to the manufacturer's instructions. The Fuji ORTHO LC™ system was cured with a 60-second exposure to blue light source (Visilux 2™, 3M, St Paul, Mn, USA), while the other systems relied on a chemical curing mechanism. The bonded teeth were stored in distilled water for 1 week at 37°C to ensure complete polymerization. Following this, the teeth were debonded using the Instron Universal Testing Machine (Instron Ltd, High Wycombe, UK) as recommended previously by Fox *et al.* (1995). Following debond each tooth was examined under the stereomicroscope and the site of bond failure recorded along with the Adhesive Remnant Index (Artun and Bergland, 1984).

Results

The bond strength characteristics of groups 1 (Dyract-Cem™), 2 (Vitremer™), and 3 (Fuji ORTHO LC™) are presented in Table 1 and compared with the control group which were bonded with Concise™ orthodontic composite resin (group 4).

Group 1 (Dyract-Cem™) had the lowest mean (11·9 N) and maximal (38 N) debond forces of the resin-modified glass ionomer cements assessed. Group 3 (Fuji ORTHO LC™) had the highest mean (59·8 N) and maximal (101 N) debond forces. ANOVA and Tukey statistical tests confirmed that groups 1, 2, and 3 all had significantly ($P < 0{\cdot}001$) lower mean debond values compared with group 4 (control). To minimize the effect of the relatively high standard deviation value for group 4 (Concise), the data was re-analysed after logarithmic transformation. The ANOVA and Tukey tests then confirmed that group1 (Dyract-Cem™) had a significantly lower mean debond value compared with the other 3 groups ($P < 0{\cdot}05$).

Weibull analysis was carried out and is represented graphically in Figure 1. From the Weibull distribution curve the probability of failure for debond at 50 N was calculated at 100 per cent for group 1, 59 per cent for group 2, and 32 per cent for group 3 compared with 5 per cent for the control group 4 (Table 1).

Table 2 shows the predominant site of bond failure and adhesive remnant index recorded after examination of the debonded surfaces under the stereomicroscope. The enamel/resin interface was the predominant site of failure at debond for the resin-modified glass ionomer cements with 100 per cent failure at this site for Dyract-cem™ (group 1) and Vitremer™ (group 2), compared with only 10 per cent in the control (group 4).

Bracket fracture was eliminated with all the resin-modified glass ionomer cements compared with a 40 per cent fracture rate with the control. The ARI scores were also reduced at 6, 10 and 16 for groups 1, 2, and 3, respectively, compared with a score of 61 for the control.

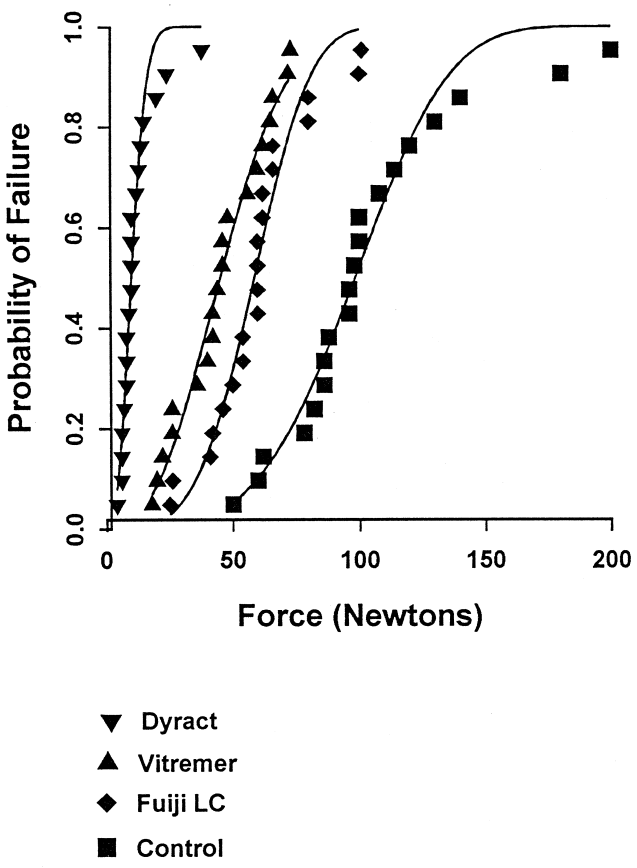

FIG. 1 Weibull curves for resin-modified and control groups.

TABLE 2 *Site of debond and Adhesive Remnant Index (ARI) for resin-modified and control groups*

Group	Enamel/ resin (%)	Bracket/ resin (%)	Bracket failure (%)	ARI (total)
1	100	0	0	6
2	100	0	0	10
3	90	10	0	16
4	10	50	40	61

1 = Dyract-cem™; 2 = Vitremer™; 3 = Fuji-Ortho LC™; 4 = Orthodontic Concise™ (control).

TABLE 1 *Bond strength characteristics for resin-modified and control groups*

Group	Mean debond force (N)	SD	Weibull modulus	Maximum debond force (N)	Characteristic force (N)	Probability of failure at 50 N
1	11·9	7·8	2·3	38	11·7	100%
2	45·5	17·3	2·5	73	52·3	59%
3	59·8	19·4	3·7	101	64·7	31%
4	103·7	37·1	3·8	200	108·4	5%

There was no evidence of enamel damage with any of the groups.

Discussion

The results of this study suggest that the resin-modified glass ionomer bonding systems are very effective at eliminating ceramic bracket debond problems. Bracket fracture was eliminated with all the resin-modified cements compared with a 40 per cent fracture rate with the composite resin control (group 4). The enamel/resin interface was the predominant site of failure (90–100 per cent) with dramatically reduced ARI scores and no evidence of enamel damage. No previous studies have assessed the use of resin-modified cements in relation to ceramic brackets. Rezk-Lega and Ogaard (1991) have assessed metal brackets with a light-cured system, and have reported similar findings to the present study with increased failure at the enamel/resin interface and less retained cement.

The elimination of debond problems appears to be related to the significantly reduced ($P < 0{\cdot}001$ using ANOVA and Tukey tests) mean and maximal debond forces compared with the conventional composite resin control. Weibull analysis confirmed an increased probability of failure at 50 N ranging from 32 per cent for the Fuji ORTHO LC™ (group 3) to 100 per cent for Dyract-Cem™ (group 1), compared with only 5 per cent for the Concise™ control (group 4).

A reduced debond force and increased probability of failure for the resin-modified cements has been reported previously (Mitchell *et al*., 1995). In this study an *in vitro* assessment was carried out comparing the bond strengths of Concise™, Vitremer™, Chemfil™, and an experimental resin-modified cement with metal brackets. It was suggested that the reduced debond forces reported for the resin-modified cements and conventional glass ionomer cement (Chemfil™) would be helpful from a debond perspective but would result in unacceptably high failure rates during treatment.

Comparing the three resin-modified cements assessed in the present study, Dyract-Cem™ (group 1) had a significantly lower mean (11·9 N) and maximal (38 N) debond force and higher probability of failure at 50 N (100 per cent). It could therefore be expected to have very high failure rates in the clinical setting. The manufacturers, however, do suggest pretreatment of the enamel with a conditioning and bonding agent in low retention situations. This was not carried out in the present study and may have contributed to the very low debond values obtained.

The Fuji ORTHO LC™ (group 3) had the highest mean (59·9 N) and maximal (101 N) debond forces, and lowest probability of failure (31 per cent) of the resin-modified cements assessed which suggests that it should be the most reliable in the clinical setting. A recent *in vitro* study (Bishara *et al*., 1998) has suggested that etching of the enamel surface can significantly increase the bond strength of Fuji ORTHO LC™ and would enhance clinical performance

No clinical studies have assessed the performance of Fuji ORTHO LC™ to date. Fricker (1994) carried out a 12-month clinical trial with an earlier light-cured resin-modified cement (Fuji II™) and reported an acceptable failure rate of 3 per cent, which was not significantly different than a composite resin control group (1·6 per cent). An earlier clinical study (Fricker, 1992) carried out with conventional glass ionomer cement had reported unacceptable failure rates of 20 per cent.

Conclusions

The resin-modified cements are very effective at eliminating ceramic bracket debond problems *in vitro*. The Fuji ORTHO LC™ cement may be the most reliable in the clinical situation since it had the highest mean and maximal debond forces and lowest probability of failure at 50 N of the resin-modified cements assessed. This should reduce the incidence of bond failure during treatment whilst maintaining its advantages in the debond situation over conventional composite bonding systems.

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