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Bond strengths between composite resin and auto cure glass ionomer cement using the co-cure technique

GM Knight,* JM McIntyre,* Mulyani*

Abstract

Background: The clinical technique for sandwich restorations prescribes etching initially set auto cure glass ionomer cement (GIC) prior to placing a layer of resin bond to develop a weak mechanical bond between composite resin and GIC. Co-curing a resin modified glass ionomer cement (RMGIC) bond and composite resin to GIC may create a chemical bond and improve the bond strengths between these two materials.

Methods: A total of 48 specimens were prepared, 12 in each of four categories. Capsulated GIC was placed into a mould and allowed to set for four minutes, etched for five seconds followed by placement of a resin bond and photo cured for five seconds over which a composite resin was puddled onto the resin bond and photo cured for 10 seconds. Capsulated GIC was placed into a mould and allowed to set for four minutes after which a sample of RMGIC (Riva LC) was prepared using twice the liquid powder ratio and painted over the surface of the set GIC using a micro brush. An increment of composite resin was added over the RMGIC and both materials were photo co-cured for 10 seconds.

Capsulated GIC was placed into a mould and RMGIC (Riva LC) that had been prepared using twice the liquid powder was brushed over the GIC (prior to initial set) followed by the placement of a layer of composite resin and photo co-cured for 10 seconds. Capsulated GIC was placed into a mould and RMGIC (Fuji II LC) that had been prepared using twice the liquid powder was brushed over the GIC (prior to initial set) followed by the placement of a layer of composite resin and photo co-cured for 10 seconds. Shear testing of each of the samples was carried out and specimens were examined to determine the nature of the fracture. Selected samples were prepared for SEM investigation to observe the interfaces between the GIC and composite resin.

Results: There were significantly lower bond strengths ($P < 0.05$) amongst samples that had been etched and bonded (2.42MPa) compared to the other samples that had been co-cure bonded with RMGIC (6.48–7.05MPa). There were no significant

differences amongst the bond strengths of the samples co-cure bonded with RMGIC. Specimens prepared by the 'etch and bond' technique failed adhesively and co-cured specimens failed cohesively within the GIC. SEM investigation showed chemical bonds between RMGIC bond and GIC and composite resin.

Conclusions: The co-cured RMGIC bonding system eliminates several placement steps and produces a significantly stronger chemical bond between GIC and composite resin than the 'etch and bond' technique. RMGIC bond and composite resin may be co-cured to GIC either before or after initial set has occurred.

Key words: Bond strength, auto cure glass ionomer cement, resin modified glass ionomer cement, composite resin, co-cure.

Abbreviations and acronyms: GIC = glass ionomer cement; RMGIC = resin modified glass ionomer cement; SEM = scanning electron microscopy.

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INTRODUCTION

The sandwich restoration comprises of a base of auto cure glass ionomer cement (GIC) replacing lost dentine with an overlay of composite resin replacing lost enamel and is a technique widely used by Australian dentists.¹

McLean *et al.*² described bonding composite resin to GIC by etching the set GIC with phosphoric acid prior to applying resin bond. The clinical technique described by Mount³ suggests etching the initially set GIC for 15 seconds prior to placing a layer of resin bond to develop a mechanical bond between the two materials. Bond strengths improve if the GIC is etched after 24 hours of maturation.^{4,5} However, this procedure requires an additional clinical visit to complete a restoration.

Resin modified glass ionomer cement (RMGIC) bonding agents have been shown to provide predictable long-term bonds between tooth structure and composite resin.⁶ Co-curing may be defined as the simultaneous photo polymerization of two different

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Table 1. Shear bond strength in megapascals of auto cure glass ionomer cement to composite resin

	Etch bond	Set co-cure Riva	Pre set co-cure Riva	Pre set co-cure Fuji
1	2.02	3.52	6.23	14.94
2	0.51	9.76	7.48	4.56
3	1.50	5.00	9.46	4.07
4	3.61	6.27	5.10	6.20
5	3.91	3.87	13.60	4.70
6	1.45	7.89	3.68	5.71
7	0.39	4.06	3.01	7.27
8	1.85	12.03	3.45	4.67
9	6.16	7.85	8.83	6.05
10	1.90	6.76	13.56	6.08
11	3.28	6.63	5.20	8.62
12	2.52	9.86	5.06	5.29
Mean	2.42	6.96	7.05	6.48
SD	1.61	2.66	3.66	2.92

light activated restorative materials. The procedure was initially used to bond composite resin and RMGIC⁷ and has been developed subsequently to incorporate a RMGIC as an intermediary bond between GIC and composite resin.

The sequential layering of GIC, RMGIC and composite resin prior to photo polymerization, and before the initial set of the GIC, enables an efficient single visit placement of a restoration although there is a lack of comparison of bond strengths between the GIC 'etch and bond' technique and co-curing.

The purpose of this study was to compare the bond strengths between GIC and composite resin using 'etch and bond', co-curing RMGIC and composite resin to GIC after initial set had occurred within the GIC and co-curing RMGIC and composite resin to GIC prior to initial set occurring within the GIC.

MATERIALS AND METHODS

Sample preparation

Clear plastic drinking straws of 6 mm diameter were sectioned in lengths of 15 mm to create moulds into which the materials would be bonded.

A total of 48 specimens were prepared, 12 in each of four categories: (1) Capsulated GIC (Riva, SDI, Melbourne, Australia) was mixed for 10 seconds using a RotoMix (3M ESPE, St. Paul, Minnesota, USA). It was then placed into the vertical mould and allowed to set for a timed four minutes. Following setting the inner surface was etched for five seconds with 37 per cent phosphoric acid (SDI) and washed with copious amounts of water and dried with oil free air. This was followed by placement of a resin bond (SDI) and photo cured for five seconds. A composite resin (Glacier, SDI) was puddled with a ball burnisher onto the resin bond and photo cured for 10 seconds; (2) Capsulated GIC (Riva, SDI) was mixed for 10 seconds using a RotoMix (3M ESPE). It was then placed into the vertical mould and allowed to set for a timed four minutes. A sample of RMGIC (Riva LC, SDI) was prepared using twice the liquid powder ratio as recommended by the manufacturer to form a creamy paste. The paste was brushed over the surface of the set GIC using a micro brush. An increment of composite resin (Glacier, SDI)

was puddled with a ball burnisher onto the RMGIC and both materials were photo co-cured for 10 seconds; (3) Capsulated GIC (Riva, SDI) was mixed for 10 seconds using a RotoMix (3M ESPE). It was then placed into the vertical mould. A previously prepared sample of RMGIC (Riva LC, SDI) that had been prepared using twice the liquid powder ratio as recommended by the manufacturer to form a creamy paste was brushed over the pre-set GIC with a micro brush, followed by gently puddling a layer of composite resin (Glacier, SDI) over the RMGIC with a ball burnisher. The sample was photo co-cured for 10 seconds; (4) Capsulated GIC (Riva, SDI) was mixed for 10 seconds using a RotoMix (3M ESPE). It was then placed into the vertical mould. A previously prepared sample of RMGIC (Fuji II LC, GC Corp., Tokyo, Japan) that had been prepared using twice the liquid powder ratio as recommended by the manufacturer to form a creamy paste was brushed over the pre-set GIC with a micro brush, followed by gently puddling a layer of composite resin (Glacier, SDI) over the RMGIC with a ball burnisher. The sample was photo co-cured for 10 seconds. After preparation each of the samples was stored in distilled water at room temperature for two weeks prior to fracture testing.

Experimental method

Samples were kept moist prior to testing to avoid any dehydration changes in the GIC that may have affected bond strengths. Shear testing of each of the samples was carried out using a Houndsfield Universal Testing Machine H50KM (Surrey, United Kingdom) with a Cross Head Speed of 1 mm per minute and a maximum loading of 200N. The specimens were placed, perpendicular to the direction of the load, on two metal rods 10mm apart. After testing, specimens were examined under a light microscope (Zeiss, Germany) at 20 times magnification to determine the nature of the fracture within the specimen.

Selected samples were prepared for scanning electron microscopy (SEM) (Philips XL30 Field Emission Scanning Electron Microscope, Netherlands) investigation to observe the interfaces between the GIC and composite resin.

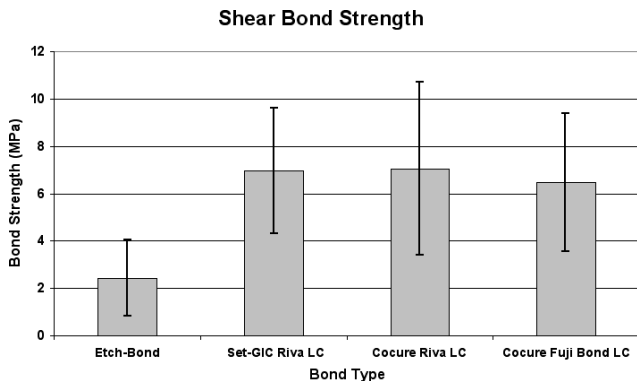


Fig 1. Mean shear bond strengths of auto cure glass ionomer cement to treated dentine samples.

Data analysis

Since the data were not normally distributed, statistical analysis using Analysis of Variance and post hoc testing to look at pairwise comparisons with no adjustment made for multiple comparisons was carried out.

RESULTS

The surface areas of the samples were each 113.14mm². Failure loads were recorded in Newtons and converted to megapascals and expressed as shear bond strengths. The recorded results are presented in Table 1 and shown graphically in Fig 1. There were significantly lower bond strengths ($P < 0.05$) amongst samples that had been etched and bonded (2.42MPa) compared to the other samples that had been co-cure bonded with RMGIC (6.48–7.05MPa). There were no significant differences amongst the bond strengths of the samples co-cure bonded with RMGIC. Apart from a few small tags of GIC remaining at the interface all specimens prepared by the 'etch and bond' technique failed adhesively. The remaining specimens that had been co-cured with RMGIC failed cohesively within the GIC.

SEM examination of the samples that had been 'etched and bonded' all demonstrated adhesive failure at the GIC composite resin interface (Fig 2). Higher magnification of a small GIC tag that remained intact

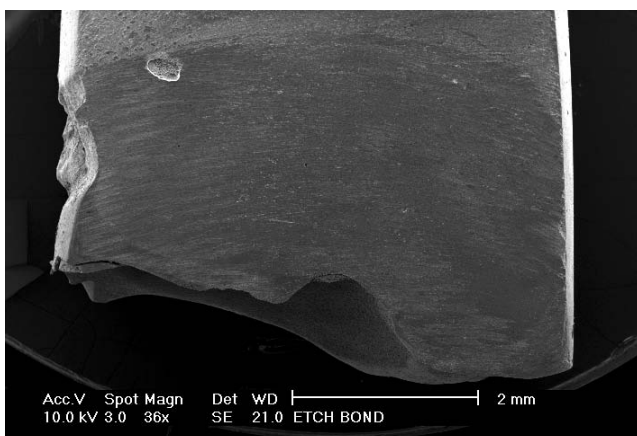


Fig 2. SEM of etched auto cure glass ionomer cement bonded to composite resin showing adhesive failure at interface.

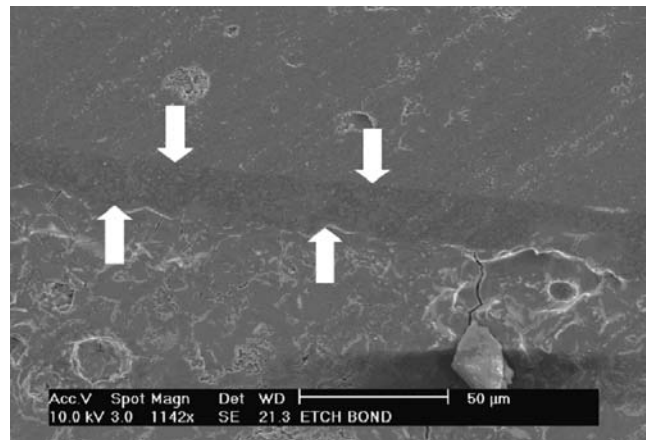


Fig 3. High resolution SEM of small tag of adhesive auto cure glass ionomer cement. Arrows show margins of resin bond between materials.

showed a close adaptation of the bond to the GIC and composite resin and there was a distinct interface between the two materials (Fig 3).

SEM examination of the samples that had been co-cured with RMGIC bond (Riva LC) and composite resin after the GIC had set showed cohesive fracture within the GIC. The presence of a gap along most of the GIC composite resin interface and other cracks in the GIC specimen was due to dehydration of the GIC during SEM preparation (Fig 4). Higher magnification of an intact bond interface showed an indistinct interface between the composite resin and GIC, suggesting that a chemical bond may have formed between the GIC and composite resin (Fig 5).

SEM examination of the samples that had been co-cured with RMGIC bond (Riva LC (Fig 6) and Fuji II LC (Fig 8)) and composite resin prior to initial set of the GIC showed that fracturing had occurred cohesively within the GIC. Higher magnification showed that although there were shrinkage cracks throughout the GIC, the restorative interface of the

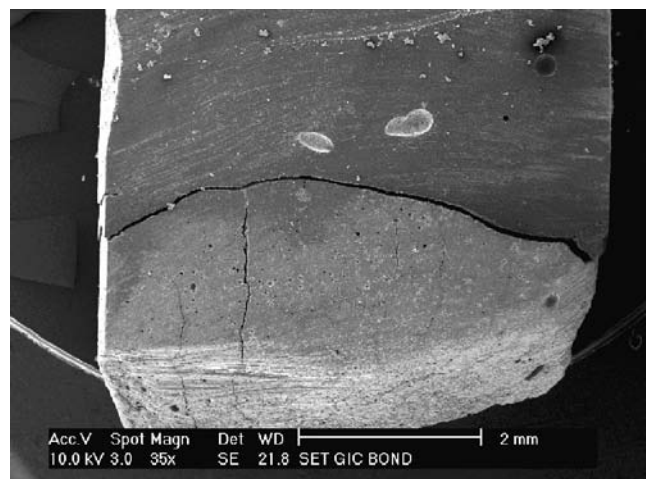


Fig 4. SEM of auto cure glass ionomer cement after initial set had occurred coated with Riva LC RMGIC and photo co-cured with composite resin showing cohesive failure within the glass ionomer cement. Interface fracture due to dehydration of glass ionomer cement during preparation for SEM.

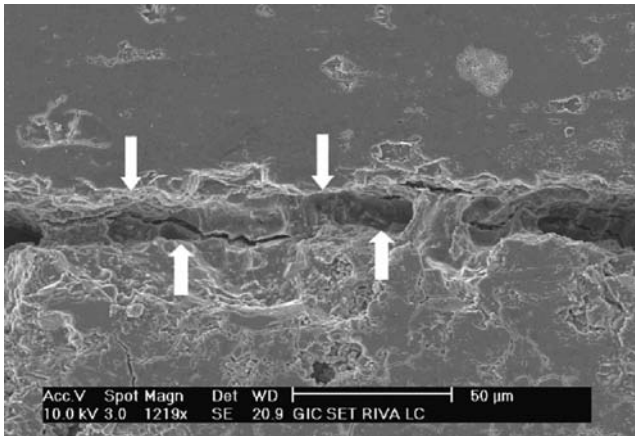


Fig 5. High resolution SEM showing interface of Riva LC RMGIC bond coated over set auto cure glass ionomer cement prior to applying and photo co-curing composite resin. Arrows show interface of RMGIC bond where the merged margins between GIC and composite resin suggest a chemical bond.

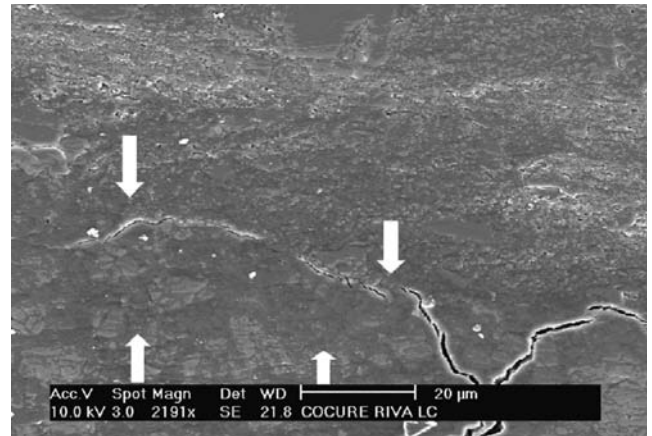


Fig 7. High resolution SEM showing interface of Riva LC RMGIC bond coated over auto cure glass ionomer cement prior to initial set and photo co-cured with composite resin. Arrows indicate interface of chemical RMGIC bond to GIC and composite resin.

samples remained intact and the merging of materials at the restorative margins confirmed a chemical bond of the RMGIC bond to the composite resin and GIC (Figs 7 and 9).

DISCUSSION

Etching GICs immediately after initial set creates a weak mechanical bond and has been shown to have a deleterious effect on the material.⁵ While waiting for 24 hours prior to etching slightly improves the bond strength, it is impractical as a clinical protocol. The co-curing technique eliminates several steps in placing a sandwich restoration and the improved chemical bond strength of RMGIC bond between GIC and composite is clearly a benefit for the restoration.

Mixing the RMGIC at twice the manufacturer's recommended liquid powder ratio creates a creamy consistency, similar to a luting cement, that is easily brushed over set or unset GIC with a micro brush.

Tyas *et al.*⁶ have shown the predictable nature of composite resin bonded to tooth structure using a RMGIC bonding system. The placement of the RMGIC bond over the surface of the GIC and cavo surfaces within a tooth facilitates placement of a layer of composite resin that can be co-cured with RMGIC bond to both the tooth and the GIC.

Allowing the GIC to reach initial set before co-curing RMGIC bond and composite resin produces chemical bond strengths beyond the cohesive strength of GIC. Co-curing RMGIC bond and composite resin onto GIC prior to initial set also produces chemical bond strengths beyond the cohesive strength of GIC. Apart from further reducing the time required to place a restoration, clinical experience has shown that the pneumatic pressure applied with a gloved thumb (prior to co-curing) creates a piston effect with the composite resin forcing the lower viscosity GIC into any voids remaining during placement of the GIC at the cavo margins. The exothermic polymerization of composite

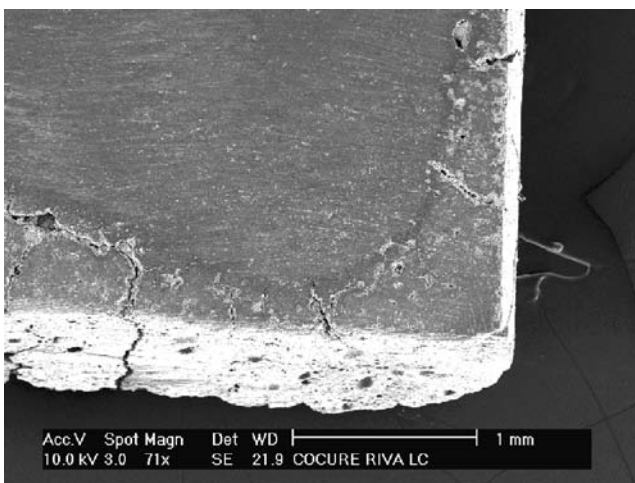


Fig 6. SEM of auto cure glass ionomer cement coated with Riva LC RMGIC bond prior to initial set and photo co-cured with composite resin showing cohesive failure within the glass ionomer cement.

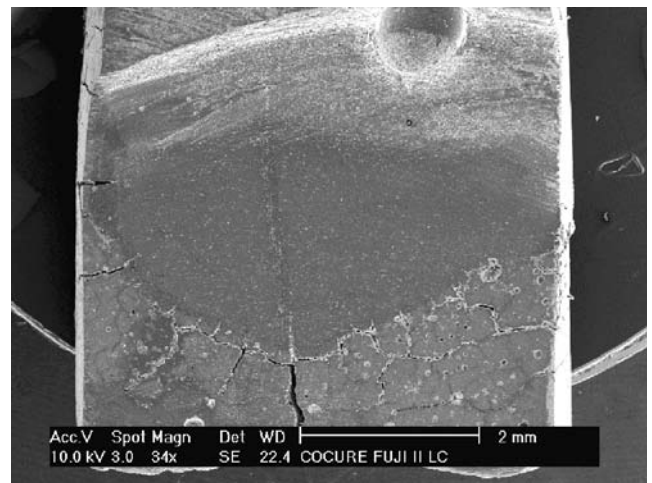


Fig 8. SEM of auto cure glass ionomer cement coated with Fuji II LC RMGIC bond prior to initial set and photo co-cured with composite resin showing cohesive failure within the glass ionomer cement.

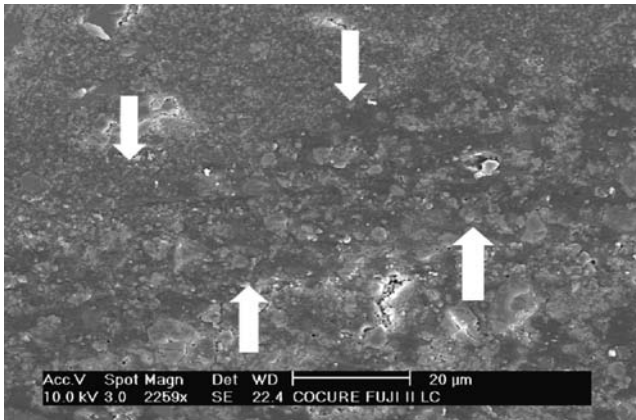


Fig 9. High resolution SEM showing interface of Fuji II LC RMGIC bond coated over auto cure glass ionomer cement prior to initial set and photo co-cured with composite resin. Arrows indicate interface of chemical RMGIC bond to GIC and composite resin.

resin heats up the surface of the pre-set GIC and may reduce the setting time of the GIC.

CONCLUSIONS

The clinical application of dental materials should aim to maximize their potential within the oral environment and the efficiency of their use. Replacing the 'etch and bond' technique of mechanically bonding GICs to composite resin with a co-cured RMGIC bonding system eliminates several placement steps and produces a significantly stronger chemical bond between GIC and composite resin. RMGIC bond and composite resin may be co-cured to GIC either before or after initial set has occurred. There are clinical

situations where co-curing prior to initial set may improve the predictability of a restoration and further reduce the time required to place it.

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