# The microleakage of a glass ionomer cement using two methods of moisture protection

K. C. Lim, B.D.S., M.Sc.*

Glass ionomer cements are highly technique-sensitive[1] but when manipulated correctly are clinically very successful.[2-5] The most critical aspect of their use is isolation from moisture for the first 30 minutes after placement[6] because premature exposure to moisture results in poor mechanical properties and clinical performance.[7] According to Earl, Hume, and Mount, the commonly used varnishes provide only a reasonable barrier against water for the newly placed glass ionomer restoration.[8] The use of the unfilled resins Heliobond (Vivadent) or Visiobond (Espe-GmbH) has been suggested as an effective alternative to varnish for protection from moisture.[9]

A recent survey of the methods used by dentists for immediate postinsertion protection of glass ionomer restorations from moisture contamination reported that 50% of dentists use an unfilled resin and 39% use varnish.[10] The purpose of the following study was to investigate the previously unreported effect of these two methods of moisture protection on the microleakage of the glass ionomer cement.

## Method and materials

The teeth used were unrestored, extracted human molars with fused roots. The teeth were stored in 10% formalin saline. Coronal access to the pulp chamber was created and the apical half of the root removed, providing apical access to the pulp chamber. Both access cavities were enlarged to the size of a No. 4 steel flat fissure bur. The pulp chamber was cleaned ultrasonically for one hour with the teeth immersed in a 1% sodium hypochlorite solution. Because ultrasonic cleaning removes the smear layer,[11] which is produced by cutting tooth tissue and can affect microleakage, a smear layer was recreated by enlarging the cavity preparations to the size of a No. 6 steel flat fissure bur.

The cavity preparations in 20 teeth were conditioned with polyacrylic acid (G-C International) for 10 seconds and were then washed with a water spray for 30 seconds and dried with an air blast for 15 seconds. Capsulated Ketac-Fil (ESPE GmbH) was agitated in an amalgamator for 10 seconds, syringed directly into the preparation, and adapted and shaped with a flat plastic instrument. The Ketac-Fil was inserted into the occlusal preparation to a depth of 3.5 mm. This was achieved with the use of a platform made by silicone-coating a No. 6 steel flat fissure bur. The platform was inserted through the apical access cavity and positioned with the aid of a WHO-designed periodontal probe which indicated an occlusal depth of 3.5 mm. The platform was removed after the restorative material had set. Ten restorations were coated with two layers of varnish (ESPE GmbH) and dried with a stream of warm air between applications. The restorations in the remaining ten teeth were coated with a film of light activated unfilled resin, Heliobond. Both the varnish and the Heliobond were applied beyond the margins of the restoration. In another group of ten teeth, the cavities were coated with two layers of varnish but no conditioning was carried out.

The positive control tooth for the electrochemical technique was filled with gutta percha, while the negative control did not have an occlusal cavity prepared.

Once filled, the teeth were placed in a humidor. The occlusal surfaces of the teeth were placed downward in a shallow container of water because the first 30 minutes after placement of the restoration is the critical period for moisture contamination of glass ionomer restorations.[6] After one hour the teeth were removed, dried, and prepared for evaluation of microleakage using the electrochemical technique as described by Mattison and von Fraunhofer.[12]

* Lecturer, University of Otago School of Dentistry, P. O. Box 647, Dunedin, New Zealand. Currently part-time lecturer, Faculty of Dentistry, National University of Singapore, Lower Kent Ridge Road, Singapore 0511.

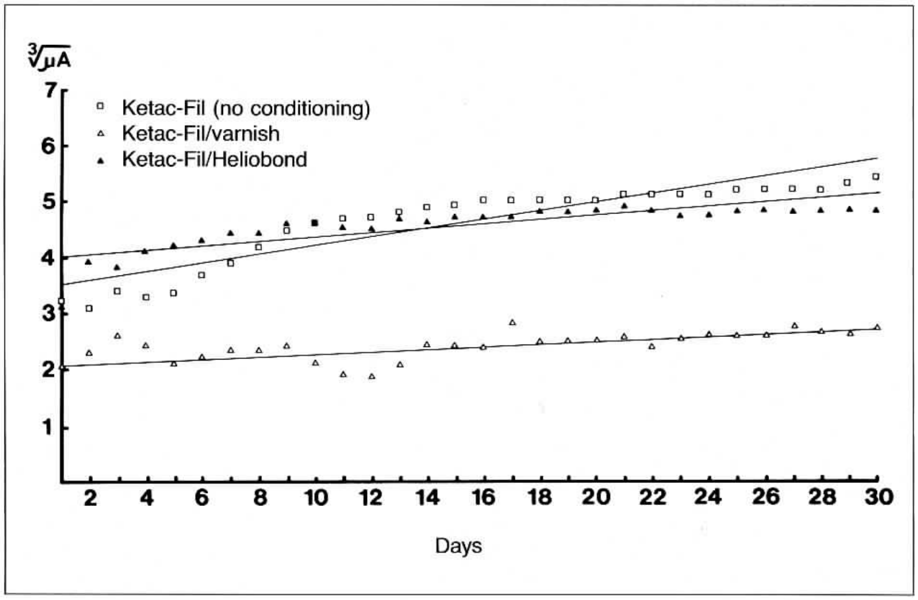


Fig. 1 Graph showing transformed mean leakage currents with time.

The bared end of an insulated copper wire 1 mm in diameter was inserted through the apical access cavity until it contacted the restoration. It was then secured in place with sticky wax. The external surface of the tooth was coated with a layer of silicone RTV sealant (Expandite Ltd.), leaving the restoration exposed. The negative control tooth was totally covered. The teeth were immersed in a 1% solution of potassium chloride at 37° C around a stainless steel tape which acted as the cathode. After 24 hours, the teeth were removed and the restorations finished with white stones. The teeth were reimmersed in the potassium chloride solution. To record the leakage current, a 10-V potential difference was applied across the anode projecting from each tooth and the cathode, and the current across an external 100 KΩ resistor was recorded daily for 30 days.

The differences in the mean current for each group were evaluated using a multivariate analysis of variance.

To clarify the reason for the difference in the leakage observed with the two methods of moisture protection, a silver-stain technique was used.[13] A further ten teeth were prepared and filled with Ketac-Fil; five restorations were protected with Heliobond and the other five with ESPE varnish. They were left to stand for two hours in a shallow dish of 1% silver chloride solution, restoration downward, then rinsed before placement into Bromophen photographic developing solution (Ilford) for a further two hours. The teeth were then sectioned for evaluation.

**Results**

*Electrochemical technique*

The mean leakage currents and standard deviations for each group are shown in Table 1. A characteristic of these studies is the large standard deviations observed[14]; therefore, the leakage currents were transformed before statistical analyses. The graph of the transformed values is shown in Fig. 1, and the results of regression analysis are presented in Table 2. Ketac-Fil/varnish without conditioning and Ketac-Fil/Heliobond both exhibited moderate amounts of microleakage, and there were no significant differences between the two ($t$ = .761, $p$ = .450, where $t$ is the variance ratio). Ketac-Fil/varnish exhibited very little microleakage throughout the experiment, significantly less than the other two groups ($t$ = 6.748, $p$ < .001). The positive control produced high leakage currents throughout the study, reaching a maximum of 958 μA, while the negative control showed no leakage.

*Silver-stain technique*

Silver was deposited between Heliobond and the tooth, forming a ring at the periphery of the restoration; however, none was observed at the varnish-tooth interface. These observations were confirmed on sectioning the teeth (Figs. 2 and 3).

**Discussion**

The results of this study show that the leakage currents recorded for Ketac-Fil restorations protected from moisture contamination by Heliobond were significantly greater ($p < .001$) than those obtained with ESPE varnish. The major route of moisture contamination could occur either through or around the protective barrier. Because Earl found Heliobond to be a superior barrier to water compared with varnish,[9] which is known to be semipermeable,[8] the greater leakage currents recorded when Heliobond was used were attributed to water contamination of Ketac-Fil around the protective barrier via the Heliobond-tooth interface, where it was applied beyond the margins of the restoration. Because the electrochemical technique provides no visual indication of what is occurring, the silver-stain technique was used to test this hypothesis. Although Heliobond may seal the exposed glass ionomer surface more effectively than varnish,[8] the silver-staining showed that gross leakage occurred between Heliobond and unetched enamel where Heliobond extended beyond the margins of the restoration, allowing moisture to reach the critical tooth-glass ionomer interface. Varnish did not permit this. This study shows that the gross water contamination at the Heliobond-tooth interface is far more detrimental to Ketac-Fil restorations than the water contamination which may occur through the semipermeable varnish barrier. Therefore, two coats of varnish rather than an unfilled resin is recommended for use for postinsertion

*Table 1* Mean leakage currents*

| | Ketac-Fil/varnish (no conditioning) | | Ketac-Fil/ varnish | | Ketac-Fil/ Heliobond | |
|---|---|---|---|---|---|---|
| Day | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| 1 | 40 | 29 | 13 | 11 | 50 | 46 |
| 2 | 38 | 33 | 16 | 12 | 64 | 30 |
| 3 | 49 | 41 | 17 | 5 | 69 | 38 |
| 4 | 45 | 34 | 15 | 7 | 75 | 34 |
| 5 | 48 | 32 | 15 | 11 | 81 | 35 |
| 6 | 60 | 38 | 18 | 17 | 84 | 35 |
| 7 | 69 | 38 | 17 | 12 | 91 | 39 |
| 8 | 81 | 42 | 17 | 11 | 92 | 42 |
| 9 | 98 | 33 | 21 | 16 | 106 | 62 |
| 10 | 102 | 34 | 19 | 20 | 111 | 68 |
| 11 | 107 | 31 | 14 | 12 | 108 | 73 |
| 12 | 107 | 28 | 14 | 10 | 100 | 55 |
| 13 | 113 | 35 | 15 | 9 | 108 | 54 |
| 14 | 118 | 38 | 24 | 22 | 107 | 54 |
| 15 | 123 | 37 | 24 | 22 | 115 | 63 |
| 16 | 125 | 40 | 23 | 20 | 115 | 66 |
| 17 | 130 | 35 | 23 | 12 | 121 | 84 |
| 18 | 130 | 42 | 21 | 11 | 119 | 72 |
| 19 | 129 | 40 | 22 | 14 | 124 | 75 |
| 20 | 132 | 41 | 20 | 11 | 120 | 66 |
| 21 | 133 | 43 | 23 | 12 | 130 | 77 |
| 22 | 134 | 44 | 22 | 16 | 117 | 62 |
| 23 | 136 | 42 | 24 | 19 | 115 | 54 |
| 24 | 139 | 42 | 26 | 21 | 114 | 65 |
| 25 | 142 | 43 | 27 | 24 | 124 | 75 |
| 26 | 145 | 54 | 28 | 28 | 119 | 61 |
| 27 | 148 | 48 | 34 | 37 | 123 | 66 |
| 28 | 148 | 49 | 31 | 38 | 117 | 59 |
| 29 | 157 | 64 | 32 | 37 | 120 | 54 |
| 30 | 160 | 63 | 31 | 33 | 117 | 58 |

* Mean current of ten teeth per group in μA.

*Table 2* Results of regression analysis

| Restoration method | *a** | *b** | Correlation coefficient | Variance ratio | Significance |
|---|---|---|---|---|---|
| Ketac/varnish (no conditioning) | 3.4696 | .0735 | .6710 | 244.1020 | <.001 |
| Ketac-Fil/varnish | 2.1187 | .0183 | .1426 | 6.1829 | .0124 |
| Ketac-Fil/Heliobond | 3.9886 | .0356 | .3274 | 35.7711 | <.001 |

* Constants for the equation $y = a + bx$

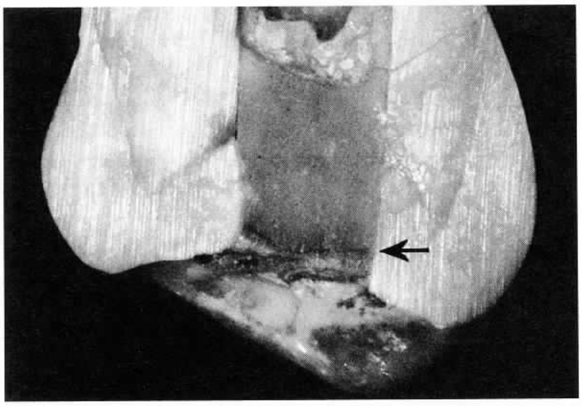

Fig. 2 Cross section of Ketac-Fil/Heliobond near the margin. The dark line(arrow) between the Ketac-Fil restoration and Heliobond was formed by deposits of silver, which indicate leakage.

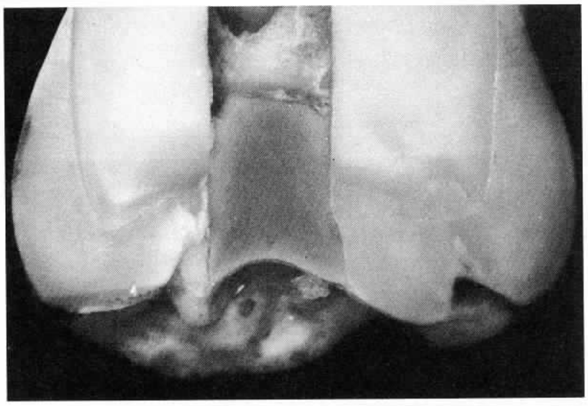

Fig. 3 Cross section of Ketac-Fil/varnish showing no leakage.

Fig. 4 Teeth 12, 11, 21, and 22 with cervical glass ionomer restorations protected with Heliobond. The opaque peripheries of the restorations indicate moisture contamination.

moisture protection of glass ionomer restorations. If the use of an unfilled resin for moisture protection is preferred, acid etching of the tooth structure surrounding the glass ionomer restoration may be necessary. A light polymerized adhesive resin which would not require the additional step of acid etching might also be effective for preventing moisture contamination of glass ionomer restorations.

The effect of greater microleakage when an unfilled resin rather than a varnish is used to prevent moisture contamination may not be immediately apparent with Ketac-Fil because it has a relatively short critical period of ten minutes,[6] and 80% of dentists surveyed used Ketac-Fil.[10] When glass ionomer cements with a longer critical period are used, then the result of water contamination which occurs when an unfilled resin is applied over it becomes apparent. This is illustrated by the case shown in Fig. 4 where a glass ionomer cement with a critical period of 30 minutes was used in a cervical restoration. Heliobond was applied for moisture protection. The central portion of the restorations shows good color, whereas the peripheries are opaque as a result of moisture contamination at the critical tooth-restoration interface.

There were no significant differences in the amount of microleakage of the teeth restored with Ketac-Fil/varnish without conditioning and Ketac-Fil/Heliobond. The graph in Fig. 1, however, indicates that the gradient is steeper in the line for leakage currents of Ketac-Fil without prior conditioning of the cavity preparation. This trend toward increasing microleakage with time may become significant in the longer term, although the differences were not significant over 30 days. Whereas, in a comparison of the restorations placed in conditioned preparations, the differences in microleakage between protection with varnish and Heliobond occurs initially, thereafter the increases of both were extremely gradual and their gradients virtually parallel. These trends illustrate the importance of conditioning the cavity preparation before restoring with glass ionomer cements.

## Conclusions

1. The immediate postinsertion protection of Ketac-Fil from moisture contamination with ESPE var-

nish was superior to that of Heliobond when evaluated in terms of microleakage ($p < .001$); therefore, the use of varnish is recommended.

2. There were no significant differences in the microleakage of Ketac-Fil/Heliobond restorations placed in cavity preparation conditioned with polyacrylic acid and that of Ketac-Fil/varnish restorations placed in preparations without conditioning.

**Acknowledgments**

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