Observations in Australia of the use of glass ionomer cement restorative material

Lennart Forsten*
Graham J. Mount†
Geoffrey Knight‡

Abstract

The aim of this study was to evaluate, with the aid of a questionnaire distributed to selected groups of dentists, the use of glass ionomer cement in different types of proximal restorations and further to evaluate any complications observed with the use of GIC. Few dentists responded in the 'Often' category regarding the observation of secondary caries or gingival inflammation in association with GIC fillings compared with about three-quarters of the dentists who reported on posterior composite resin restorations. Tunnel cavities had been prepared and restored by 54 per cent of the dentists, simple proximal restorations in primary molars by 89 per cent and 'sandwich' restorations by 69 per cent. Few dentists with at least two years experience with tunnel restorations observed biological complications, but fracture of the marginal ridge was reported in the 'Often' category by 12 per cent. Among the dentists with at least five years experience with proximal restorations in primary molars 59 per cent of the operators mentioned more complications with these than with amalgam restorations. Biological complications were not a great problem with glass ionomer/composite laminates but wear or dissolution of the proximal GIC surface was recorded in the 'Often' section by 14 per cent of those placing them.

Key words: Glass ionomer cement, restorative dentistry, cariology.

(Received for publication May 1993. Revised August 1993. Accepted November 1993.)

Introduction

The advantages of using glass ionomer cement (GIC) in restorative dentistry are mainly biological in as much as it demonstrates adhesion to both enamel and dentine,[1,2] has an anticariogenic effect due to the long term release of fluoride,[1-3] and also shows a certain inhibitory effect on the growth of bacteria on the surface of the restoration.[4,5] Its use as a restorative material, however, is limited because it has a low resistance to fracture. Therefore, if a restoration is to be placed in a load bearing area, there are two main methods of compensating to extend the potential life span. Firstly, the stress-bearing area of the restoration may be kept to a minimum by preparing a micro-cavity and maintaining as much natural tooth structure as possible.[5-12] Secondly, if the carious lesion is too large for a micro-cavity, the cement may be laminated with amalgam or composite resin to protect it from load.[13] This is the so-called 'sandwich' restoration where the GIC is used as a dentine replacement and the stronger material is an enamel substitute.

Criticism has been directed towards both the tunnel[14,15] and the 'sandwich' restoration,[16] and there are only a few clinical studies available on their clinical performance. In spite of this there has been a notable increase in use of these techniques in the Nordic countries over the last ten years. In order to derive a more accurate picture of the present situation regarding frequency of use, a questionnaire was distributed during continuing education courses in Finland, Sweden, and Norway during 1991,[17,18] and dentists were invited to detail their experiences in clinical practice.

There is anecdotal evidence of a similar pattern of use in Australia so the present study was undertaken using the same questionnaire to seek confirmation of this presumption. It seemed desirable at the same time to determine the success/failure pattern for such restorations and determine if there was a difference between countries.

It could be assumed at this time that the advent of the dual-cure glass ionomer cements has made this survey out of date. However it is suggested that, although the physical properties of the dual-cure cements are superior to the auto-cure varieties, both materials are still of value for the

*Department of Cariology, Institute of Dentistry, University of Turku, Finland.
†Visiting Research Fellow, University of Adelaide.
‡Private Practitioner, Brighton, Victoria.

Table 1. Questionnaire

1. How often have you noticed in posterior restorations

	Never	Seldom	Often
1. Caries in association with GIC fillings?			
2. Caries in association with composite fillings?			
3. Gingival inflammation with GIC fillings?			
4. Gingival inflammation with composite fillings?			

2. For how long have you been making tunnel fillings?
   1. >5 years 2. 2-5 years 3. 0.5-2 years 4. Never
3. Have you observed complications with tunnel fillings?

	Never	Seldom	Often
1. Pulpal symptoms			
2. Residual caries			
3. Secondary caries			
4. Marginal ridge fracture after placement			
5. Other complications What?			

4. For how long have you used GIC for proximal fillings in primary molars?
   1. >5 years 2. 2-5 years 3. 0.5-2 years 4. Not at all
   5. I have no young patients
5. Have you observed more complications using GIC in primary molars than when using amalgam?

	No	Yes
1. Pulpal symptoms		
2. Secondary caries		
3. Lost fillings		
4. Fractured fillings		

6. For how long have you been making GIC/composite 'sandwich' restorations as shown in the diagram?
   1. >5 years 2. 2-5 years 3. 0.5-2 years 4. Not at all
7. Have you observed complications with this type of 'sandwich' restorations?

	Never	Seldom	Often
1. Pulpal symptoms			
2. Secondary caries			
3. Proximal caries on adjacent tooth?			
4. Proximal wear or dissolution of GIC?			
5. Other complications What?			

techniques described here. There will always be situations where problems of access will make an auto-cure cement the material of choice so the dual-cure cements cannot be regarded as universal.

Material and methods

The questionnaire was a translation from Finnish into English of the one used in Finland early in 1991 (Table 1). In connection with 'Question 6', a diagram of the 'sandwich' restoration was included to eliminate any possible confusion concerning design (Fig. 1). It was

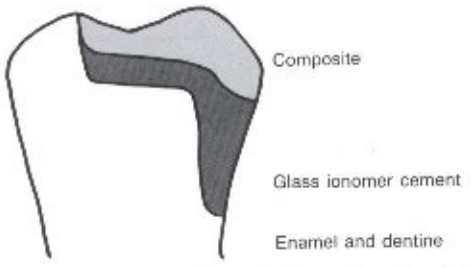

Fig. 1. – Schematic drawing of the 'sandwich' restoration as shown in the questionnaire.

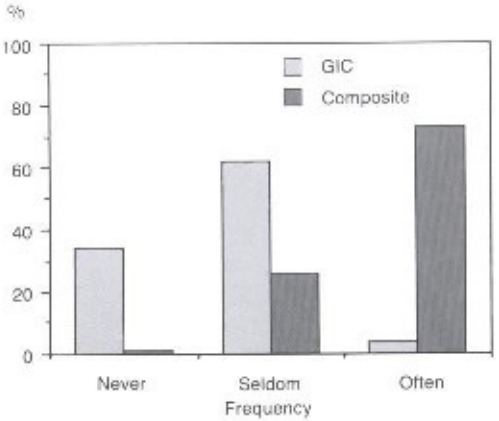

Fig. 2. – Frequency (%) of dentists (n = 324) observing caries in association with GIC and composite fillings.

distributed at the start of several continuing education courses held by the authors in Australia during the years 1991-92, and was generally collected prior to the completion of the course. There were 630 forms returned in Scandinavia and 324 in Australia and the results were analysed and the tables drawn up by one author (LF).

Results

The answers in the questionnaire revealed that most practitioners responded in the 'Never; or 'Seldom' categories for both secondary caries (Fig. 2) and gingival inflammation (Fig. 3) in association with glass ionomer restorations compared with composite resins where most dentists responded in the 'Often' category for both secondary caries and gingival inflammation. Also, it is apparent that many dentists use tunnel cavity designs (Fig. 4) and very few report any biological problems arising

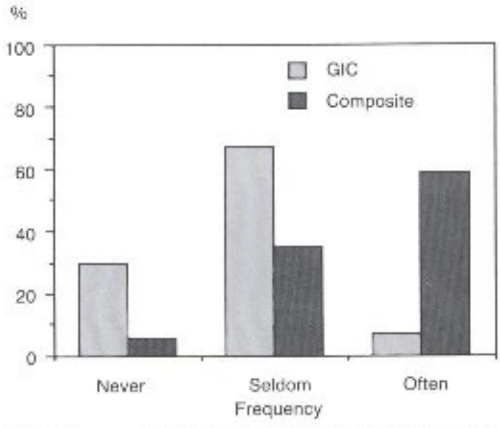

Fig. 3. – Frequency (%) of dentists (n = 324) observing gingival inflammation in association with GIC and composite fillings.

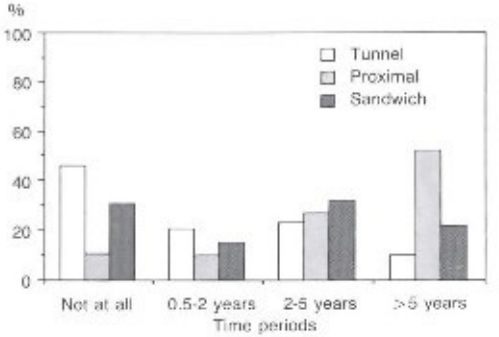

Fig. 4. – Frequency (%) of dentists (n = 324) using GIC in tunnel preparations, in proximal cavities of primary molars and in 'sandwich' restorations for different periods of time.

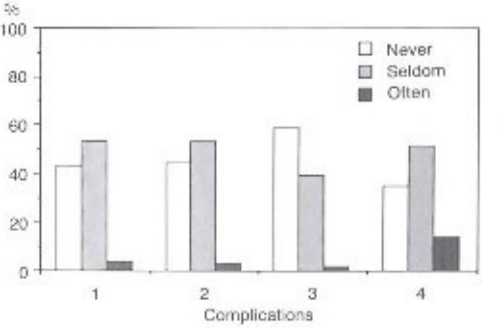

Fig. 6. – Frequency (%) of dentists (n = 172) observing complications with 'sandwich' restorations. Method in use >2 years. 1: Pulpal symptoms, 2: secondary caries, 3: proximal caries on adjacent tooth, 4: proximal wear or dissolution of GIC.

from them (Fig. 5). There were only five dentists who noted problems and these included incomplete filling of the tunnel (3), a difficult technique to carry out (1) and difficulty of control in the presence of old restorations (1).

It would appear that the use of GIC on the proximal surface of primary molars is very popular as a total of 169 dentists had been restoring these lesions with the cement for more than five years (Fig. 4). Of these, 59 per cent had observed more complications in association with the cement than with amalgam; 78 per cent reported lost restorations; while 59 per cent reported fractures as a problem. Only 4 per cent reported pulpal complications and 7 per cent reported recurrent caries.

The technique for lamination of glass ionomer cement with composite resin is shown diagrammatically in Fig. 1. Sixty-five per cent of those answering the questionnaire used approximately the same technique. In fact, 172 dentists reported more than two years experience with this method. Biological problems such as pulp symptoms, secondary caries or proximal caries in adjacent teeth had been observed in the 'Often' category by only very few of these operators. The physical problem observed in the 'Often' category by more than 14 per cent of the dentists

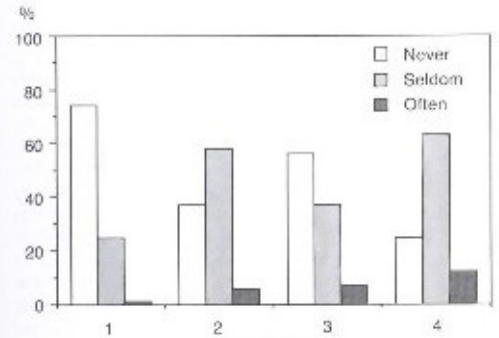

Fig. 5. – Frequency (%) of dentists (n = 107) observing complications with tunnel fillings. Method in use >2 years. 1: Pulpal symptoms, 2: residual caries, 3: secondary caries, 4: marginal ridge fracture after placement.

was proximal dissolution or wear of the proximal cement. Furthermore, 8 dentists mentioned occasional fracture of the composite resin layer (7 'Seldom'; 1 'Often') and 4 reported debonding or chipping between the cement and the resin (9 'Seldom'; 5 'Often'). Two recorded as 'Often' the staining of the interface between the two materials; 5 operators recorded problems 'Often' with contact points; and only one respondent recorded in the 'Seldom' category, wear of the composite resin.

In Table 2, the frequency and time period over which Australian dentists have used these techniques are compared with their counterparts (n = 630) in the Nordic countries as shown by the earlier survey.[18] Although there were more Australian than Nordic dentists without experience of the tunnel and 'sandwich' techniques there were many more Australian dentists with more than five years experience restoring both permanent and deciduous teeth.

Anecdotal evidence had suggested previously that the pattern of usage of glass ionomer cements and the usage of micro-cavity designs were similar in Australia and the Nordic countries. The current surveys confirmed this assumption (Table 2). Tunnel restorations are used by 54 per cent of Australian dentists compared with 60 per cent of Nordic operators. The figures for proximal restorations are further apart at 78 per cent compared with 89 per cent and the 'sandwich' restorations show a similar difference at 69 per cent compared to 80 per cent. Furthermore, the overall numbers using these techniques in both countries suggest that they could be regarded as standard routine restorative procedures.

Discussion

As there were no demands for clarification, it was assumed that the questionnaire was clearly worded. As it was not designed to reveal the frequency of dentists generally using GIC, it is possible that some who filled in the questionnaire had no experience at all in these techniques. To maintain the simplicity and avoid difficulties of interpretation no distinction was made between 'own' and 'others' restorations. As it was designed primarily to elicit the frequency of problems and complications, it was

Table 2. Difference between Australian (A) and Nordic (N) dentists in the use of different methods (%)

Time period (years)	Method								
	Tunnel			Proximal			Sandwich		
	A	N	Difference	A	N	Difference	A	N	Difference
0*	46	40	+6	11	22	−11	31	20	+11
0.5-2	21	30	−9	10	10	0	15	25	−10
2-5	23	27	−4	27	10	−17	32	25	−7
>5	10	3	+7	52	23	+29	22	7	−15

*Method not used at all.
+Indicates that the percentage of Australians is higher.
−Indicates that the percentage of Australians is lower.

not considered important to know who had actually placed the restorations.

To distinguish between the two subjects, both 'Not at all' and 'Never' were used in the questionnaire: 'Not at all' in relation to frequency of use, and 'Never' in connection with frequency of complications. In association with the questions concerning clinical complications, the words 'Never', 'Seldom' and 'Often' were used. 'Never' and 'Seldom' represent almost the same experiences, but 'Never' was used because, if possible, a firm decision was desirable. 'Seldom' was used because it was assumed that many people do not desire to make a firm decision. However, 'Never' was used surprisingly often.

Due to the biologically desirable properties of glass ionomer cement, including fluoride release, it would be expected that recurrent caries would be a greater problem with composite resin than the cement. Both *in vitro* and *in vivo* studies conducted previously confirm this assumption,[1-4,19] and this survey is further evidence of the value of the glass ionomer cement. Previous work has suggested that there is less plaque in the presence of glass ionomer cement because of the fluoride release, and this would suggest that there may be less gingival inflammation in relation to a cement restoration compared with amalgam.[20] This assumption was confirmed in this study.

One of the main advantages of the tunnel cavity design is the ability to preserve remaining natural tooth structure which has not been already involved in the caries process.[21] The profession has become more aware of such conservative techniques in the presence of adhesive restorative materials in recent years and this survey suggests that there are many dentists prepared to attempt alternative cavity designs with this in view. It was interesting to note the relatively low numbers of problems reported with the tunnel technique in spite of the fact that it is not yet taught in the undergraduate curriculum in most dental schools.

The low failure rate suggests that the tunnel design is not particularly 'technique sensitive', but rather relies on a careful approach with good visibility, illumination and magnification. In the presence of fluoride, remineralization of the early carious lesion is very reliable[22] and, therefore, penetration through the proximal enamel is not necessary if that surface is not already cavitated. If, following removal of the carious dentine with small round burs, the enamel surface remains intact although demineralized, it is not necessary nor desirable to break out to the proximal surface. Maintenance of intact proximal enamel can facilitate the preparation and restoration of the cavity and help to maintain the integrity and strength of the marginal ridge.

On the other hand, if the enamel is cavitated, it is necessary to carefully clean the periphery of the enamel lesion with very small chisels or a triple angled excavator§ without removing any sound intact enamel at all. If the marginal ridge has cracked prior to or during insertion of the glass ionomer cement, the only modification required to the restoration is the removal of the cement from the fracture site and the placement of a small amount of composite resin. The adhesion of the cement will reinforce the marginal ridge to a considerable degree[20] and the only contra-indication would be the presence of an unduly heavy occlusal load on the marginal ridge.

The use of GIC for the restoration of small proximal lesions in deciduous molars is relatively more common in Australia than in the Nordic countries. This is a little surprising considering the relatively negative attitude to amalgam in Sweden, in particular. However, the relatively high problem rate suggests that there is a need for further research into effective cavity designs. The use of a tunnel is restricted by the small size of the tooth, although it is possible to restore the distal of second deciduous molars in this fashion on occasion.

Experience suggests that, for the proximal box cavity, there should be an absolute minimum of occlusal involvement in the cavity design and enamel contact with the adjacent tooth should be maintained if possible. Undermined enamel does not need to be removed because the adhesion of the cement will offer considerable support. There is little need for the inclusion of retentive elements in the design and the pulp tolerance of the cement is such that there is probably no need to line the cavity at all.

It would seem that the sandwich restoration as described in Fig. 1 is becoming standard in Australia as it is in the Nordic countries. The relatively lower physical properties of the cement are adequately compensated by the composite resin and there are few operators reporting problems.[23,24] It is important to develop full physical properties in both materials. Wear of the exposed glass ionomer cement in the interproximal regions reported by 14 per cent of dentists may be the result of using a cement with a low powder/liquid ratio. Providing the strongest cement available is used, and it is placed in sufficient

§Mcl. I. Cavit, London.

thickness, the cement will not crack or disintegrate and its lack of fracture resistance will be overcome by the resin. Composite resin, of course, is relatively flexible and requires reasonable bulk and good adhesion to the surrounding enamel to maintain stability under load.

It should be noted that this survey was conducted prior to the advent of the dual-cure glass ionomer cements. As the resistance to fracture and dissolution of these cements are generally about 25-50 per cent better than the auto-cure cements,[25] it is suggested that many of the problems and limitations in these techniques can be reduced. In the true dual-cure cement, the part cured by light activation and any remainder in the depth of the cavity which is subsequently auto-cured will have similar or identical physical properties. They are all radiopaque and are relatively easily placed. Because of the presence of the additional resin there is no need to etch the cement to develop adhesion between the cement and the resin although it is not deleterious to do so. It is recommended, therefore, that the dual-cure cements be utilized always where there is likely to be an occlusal load as well as in the sandwich technique. However, the auto-cure cements are certainly not outdated because there will be situations where they remain the material of choice and they are still very useful materials.

Conclusion

The information obtained in this and previous studies offers largely anecdotal information concerning the use of glass ionomer cements particularly in the three clinical situations described. The results are based on answers to a questionnaire offered to participants at continuing education courses which were designed to discuss these techniques and, therefore, it is possible that the students could be regarded as already biased. Furthermore, the answers offer overall impressions and opinions rather than a systematic collection of actual numbers of restorations, failures, and problems. Therefore, it is not possible to offer any definite conclusions. However, this survey combined with those carried out in the Nordic countries suggests that there are no serious biological problems associated with the recommended techniques described, and the anti-cariogenic properties as well as the pulp compatibility of the glass ionomer cements appears to be confirmed again.

References

1. Walls AGW. Glass polyalkenoate (glass ionomer) cements: a review. J Dent 1986;14:231-46.
2. Mount GJ. An atlas of glass ionomer cements. A clinician's handbook. London: Dunitz, 1989.
3. Tyas MJ. Cariostatic effect of glass ionomer cement: a five-year clinical study. Aust Dent J 1991;36:236-9.
4. Serra MC, Cury JA. The *in vitro* effect of glass-ionomer cement restoration on enamel subjected to a demineralisation and remineralisation model. Quintessence Int 1992;23:143-7.
5. Forsten L. Short- and long-term fluoride release from glass ionomers and other fluoride containing filling materials *in vitro*. Scand J Dent Res 1990;98:179-85.
6. Svanberg M, Mjör IA, Örstavik D. Mutans streptococci in plaque from margins of amalgam, composite and glass ionomer restorations. J Dent Res 1990;96:861-4.
7. Berg JH, Farrell JE, Brown LR. Class II glass ionomer/silver cermet restorations and their effect on interproximal growth of mutans streptococci. Pediatr Dent 1990;12:20-3.
8. Forsten L, Karsalainen S. Glass ionomers in proximal cavities of primary molars. Scand J Dent Res 1990;98:70-3.
9. Cross TP, Phillips RW. Six years experience with glass-ionomer-silver cermet cement. Quintessence Int 1991;22:783-93.
10. Hunt PR. Microconservative restorations for approximal carious lesions. J Am Dent Assoc 1990;120:37-40.
11. Knight GM. The tunnel restoration – nine years of clinical experience using encapsulated glass ionomer cements. Case report. Aust Dent J 1992;37:245-51.
12. Hasselrot L. Tunnelpreparationer. Traditionella och alternativa metoder. Tandläkartidningen 1990;82:1114-26.
13. McLean JW, Powis DR, Prosser MJ, Wilson AD. The use of glass-ionomer cements in bonding composite resin to dentin. Br Dent J 1985;158:410-4.
14. Hickel R, Voss A. Untersuchungen zur Tunnelpräparation. Deutsche Zahnärtl Z 1987;42:943-8.
15. van Wuis H, Krejci I, Lutz F. Die Tunnelrestauration. Ei des Kolumbus oder Kuckucksei? Schweiz Monatsschr Zahnmed 1988;98:1105-8.
16. Welbury RR, Murray JJ. A clinical trial of the glass-ionomer cement-composite resin "sandwich" technique in Class II cavities in permanent premolar and molar teeth. Quintessence Int 1990;21:507-12.
17. Forsten L. Clinical experience with glass ionomer fillings. J Dent Res 1992;71:SpIss:1095:Abstr 73.
18. Forsten L. Clinical experience with glass ionomer for proximal fillings. Acta Odontol Scand 1993;51:195-200.
19. Barkhordar RA, Kemplar D, Pelaner RRB, Stark MM. Anti-microbial action of glass ionomer lining cement on *S. mutans* and *S. mutans*. Technical note. Dent Mater 1989;5:281-2.
20. Svanberg M, Krasse B, Ostenfeldt H-O. Mutans streptococci on interproximal plaque from amalgam and glass ionomer cement. Caries Res 1990;24:133-6.
21. Hill FJ, Halusch FJ. A laboratory investigation of tunnel restorations in premolar teeth. Br Dent J 1988;165:364-7.
22. Kidd EAM, Joyston-Bechal S. The effect of acid-etching followed by fluoride application on the development of artificial carious lesions around amalgam restorations. Br Dent J 1984;157:349-53.
23. Mount GJ. Clinical requirements for a successful 'sandwich' – dentine to glass ionomer cement to composite resin. Aust Dent J 1989;34:259-65.
24. Mount GJ. Esthetics with glass ionomer cements and the "sandwich" technique. Quintessence Int 1990;21:93-101.
25. Mount GJ, Makinson OF. The strength of light-cured materials: the shearpunch test. Dent Mater (in press)

Address for correspondence/reprints:
G. J. Mount,
13 MacKinnon Parade,
North Adelaide, South Australia 5006.