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# Heat-treated glass ionomer cement fissure sealants: retention after 1 year follow-up

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**Objective.** The aim of this study was to assess the retention rate of glass ionomer cement (GIC) fissure sealants heated during setting time.

**Methods.** One hundred and twelve teeth with well-delineated fissure morphology were sealed with composite resin and GIC. Composite resin (Helioseal F, Vivadent) was used in control group A (56 teeth). GIC (Fuji VII, GC) was applied using split-mouth design with conditioning in group B (26 teeth) and without surface conditioning in group C (30 teeth). GIC was heated with external heat source (Elipar Trilight, Espe) for 40 s during the setting time according to the manufacturer's instructions. Fissure sealants were evaluated 1 year after clinical service.

**Results.** Retention rate in group A was 80.4% after 1 year of clinical service. Group B showed retention rate of 30.8%, and group C of 26.7%. Two new caries lesions were detected in groups B and C. Significant differences in retention between the composite group and GIC groups were obtained by Kruskal–Wallis and Mann–Whitney tests.

**Conclusion.** It could be concluded that retention rate of GIC sealing treated with heat during setting time was significantly lower than retention of conventional composite resin. The heating procedure during setting of GIC sealants cannot be recommended as routine treatment in clinical practice.

## Introduction

Pit and fissure sealant use is an effective clinical regime available for preventing occlusal caries[1–3]. The most widely used fissure sealants are based on bis-glycidyl methacrylate (Bis-GMA) resins. These resins were first introduced as restorative materials in 1963[4]. Cueto and Buonocore suggested the sealing of pits and fissures with an adhesive resin in 1967[5]. A second group of materials used as fissure sealants are the glass polyalkenoate cements[6–10]. To achieve maximum caries preventive effect on occlusal surfaces, dental sealants should have several properties. Perfect adhesion of material should be maintained not only while setting, but also during function (including challenge of thermal and mechanical cycling). Dimensional changes of material during application should be minimal. Complete retention of sealant material in the occlusal fissures depends for a long time on the dimensional changes, resistance to wear and fracture along with easy handling, and powerful preventive effect. Good preventive effect today means substantial release of fluoride ions[11,12]. Morphis *et al.*[13] reviewed the literature on the effectiveness of fluoride-releasing sealants. There is an evidence for equal retention rates to conventional sealants, *ex vivo* fluoride release, and reduced enamel demineralization. Glass ionomer cements (GICs) are also proposed for pit and fissure sealant materials. They have several advantages compared to classic resin sealant materials: lower susceptibility to moisture, easy handling, and fluoride releasing at a continuous rate[11,12]. However, different studies have shown significantly lower retention rate compared to resin sealants[14–17]. The mechanical properties of glass ionomers are inferior to resin materials. The question of the caries preventive effect of glass ionomer sealants is still controversial: different studies have shown different preventive effects[10,14,16,18,19]. It was suggested that after loss of sealant, the eventual presence of material remnants in the fissures can maintain caries prevention[18,20,21].

The treatment of glass ionomer material with heat was recently introduced[22]. The idea

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of this procedure was to heat material to 60–70 °C which enables command set of classical (chemically cured) material and increases the mechanical properties of material. Sidhu *et al*. describe the increase of mechanical properties because of contraction and loss of water in material on heating[22]. Some studies also showed increased bond strength of glass ionomers to hard dental tissues[23].

The aim of this study was to investigate the retention rate of glass ionomer sealant material treated with heat during setting time after 1-year clinical trial. This paper reports the findings at recall after 12 months.

## Materials and methods

Ethical approval for the study was obtained from the ethical committee of the School of Dental Medicine, University of Zagreb. Informed consents were received from all parents of participating children. Children with an age range of 6–16 years attending the Department of Paediatric Dentistry at the School of Dental Medicine in Zagreb were included in the study. Sixty-two patients were recruited in this study with 124 sealed teeth. Two molars were sealed per person. After 1 year, 56 children with 112 sealed molars were available for examination. All the molars included were fully erupted with their contralateral tooth present. Clinical examination with dental probe established that molars were caries free, with absence of mobility caused by periodontal disease, and with no evidence of hypoplasia or history of previous sealant application.

The study material comprised of 112 teeth, first and second molars, with well-delineated fissure morphology, divided into three groups using split-mouth design. Each pair of teeth was sealed with composite sealant material Helioseal F (Ivoclar Vivadent, Schaan, Liechtenstein), which served as the control group, and glass ionomer material Fuji VII (GC Corporation, Tokyo, Japan) applied with or without surface conditioning (Dentin Conditioner, GC Corporation).

The teeth on the left side of the mouth were sealed with GIC groups, whereas the teeth on the right side were sealed with resin sealant. Heating of glass ionomer sealant was performed with conventional polymerization unit Elipar Trilight (3M Espe Dental Products, Seefeld, Germany) standard mode at 750 mW/cm$^2$. An infrared thermometer PCE-889 (PCE Group, Meschede, Germany) was used for recording temperature changes. All sealants were clinically evaluated by two researchers, using criteria proposed by Kilpatrick *et al*.[24]

### *Application of fissure sealant*

Isolation of teeth was performed with cotton rolls and high-volume suction.

In group A, the occlusal surface of each tooth was cleaned with pumice, washed and dried, and isolated with cotton wool rolls and high-volume suction. The teeth were etched for 20 s with 37.5% phosphoric acid (Kerr Etchant, Kerr, Orange, CA, USA). Enamel was rinsed and dried for 20 s following material application and polymerization. Group A consisted of 56 first and second permanent molars sealed with Helioseal F (Ivoclar Vivadent).

In group B, after cleaning with pumice, enamel was conditioned with dentin conditioner (10% polyacrylic acid) for 20 s, rinsed, and dried for 20 s. Then, glass ionomer material was applied and command set with heating for 40 s. The temperature was recorded before and after 40 s of illumination ($\Delta T$ = 3 °C). Group B consisted of 26 first and second permanent molars sealed with Fuji VII (GC).

In group C, the same procedure of enamel preparation was performed, but glass ionomer material was applied without enamel conditioning. After application, the sealant was heated for 40 s. The temperature was recorded before and after 40 s of illumination ($\Delta T$ = 3 °C). Group C consisted of 30 first and second permanent molars sealed with Fuji VII (GC).

The evaluation criteria concerning retention of sealant was classified as: (i) type 1: intact sealant; (ii) type 2: 1/3 of sealant missing; (iii) type 3: 2/3 of sealant missing; and (iv) type 4: whole sealant missing[24].

The presence of new caries lesions was evaluated in two categories: 1 – absent; 2 – present.

Obtained data were analysed using non-parametric Kruskal–Wallis and Mann–Whitney tests.

**Table 1. Helioseal F and Fuji VII retention after 12-month recall (A1, inact sealant; A2, 1/3 of sealant missing; A3, 2/3 of sealant missing; A4, whole sealant missing (Kilpatrick *et al.*)[24].**

| | Sealant retention after 12 months | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type of sealant retention | | | | | | | | | | |
| | A1 | | A2 | | A3 | | A4 | | Total | | |
| Sealing material | *n* | % | *n* | % | *n* | % | *n* | % | *n* | % | Kruskal–Wallis (*P*) |
| Helioseal F | 45 | 80.4 | 5 | 8.9 | 3 | 5.4 | 3 | 5.7 | 56 | 100 | |
| Fuji VII with conditioning | 8 | 30.8 | 9 | 34.6 | 5 | 19.2 | 4 | 15.4 | 26 | 100 | |
| Fuji VII | 8 | 26.7 | 11 | 36.7 | 6 | 20 | 5 | 16.7 | 30 | 100 | |
| Total | 61 | | 25 | | 14 | | 12 | | 112 | | $P < 0.0001$ |

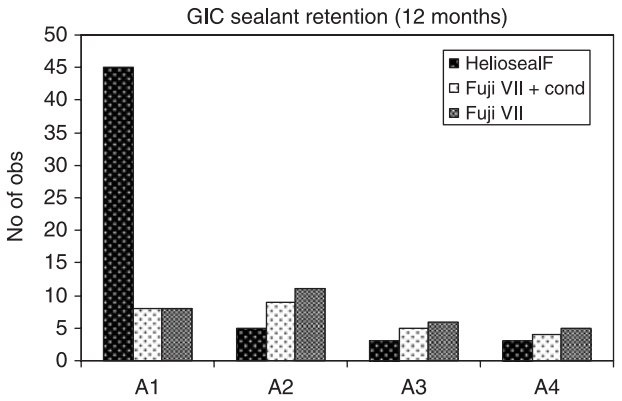


**Fig. 1.** Retention of fissure sealants in first and second permanent molars at 12 months follow-up. A1, inact sealant; A2, 1/3 of sealant missing; A3, 2/3 of sealant missing; A4, whole sealant missing. GIC, glass ionomer cement.

The presence of GIC material remnants in fissures after loss of sealant was detected with a scanning electron microscope (SEM) (XL30, Philips, Eindhoven, The Netherlands). The impressions with polyvinylxyloxane impression material of GIC-sealed teeth were taken in order to obtain replicas of occlusal surfaces. For that purpose, impression was taken and poured in acrylic resin (CitoFix Kit, Struers A/S, Ballerup, Denmark). The obtained replicas were analysed with SEM.

## Results

Two investigators evaluated all sealed surfaces. Correlation between investigators was very high (90%). In the cases, which were rated differently, a mutual agreement was found. The results of retention rates of fissure sealants at 12 months follow-up are presented in Table 1. Complete retention rate in the control group (Helioseal F resin sealant) after 12 months was 80.4%, with only three sealants (5.4%) completely missing. In group B (Fuji VII with surface conditioning), the complete retention was observed only in 30.8% with 15.4% completely missing sealants. In group C, the complete retention was found in 26.7% of sealants and 16.7% completely missing. The Kruskal–Wallis test revealed a significant difference between the control group (resin sealant) and the glass ionomer groups.

This could be clearly seen in histograms showing a very low incidence of A1 criteria (intact sealant) for the GIC groups, comparing to the resin sealant group (Fig. 1).

The Mann–Whitney test showed a significant statistical difference between Helioseal F (group A) and both glass ionomer groups. There was no significant difference in retention between the glass ionomer groups, with and without surface conditioning. The same pattern in retention rate was noted in the maxilla and mandible, with no significant statistical difference in retention between the upper and lower jaw.

The control group showed no secondary caries lesions after 12 months, but in both glass ionomer groups one new caries lesion was detected (Table 2). Thus, in the GIC groups in total, two new caries lesions were detected after 12 months. In group B, sealant showed incomplete retention (more than 1/3 loss), and in group C, complete absence of the material was noted. This record, however, has no statistical significance.

**Table 2. Incidence of new caries lesions after 12 months follow-up (1, absent caries; 2, present caries).**

| | New caries lesions after 12 months follow up | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | Total | | |
| Sealing material | *n* | % | *n* | % | *n* | % | Kruskal–Wallis (*P*) |
| Helioseal F | 56 | 100 | 0 | 0 | 56 | 100 | |
| Fuji VII with conditioning | 25 | 96.2 | 1 | 3.8 | 26 | 100 | |
| Fuji VII | 29 | 96.7 | 1 | 3.3 | 30 | 100 | |
| Total | 110 | 98.2 | 2 | 1.8 | 112 | 100 | 0.3608 NS |

NS, not significant.

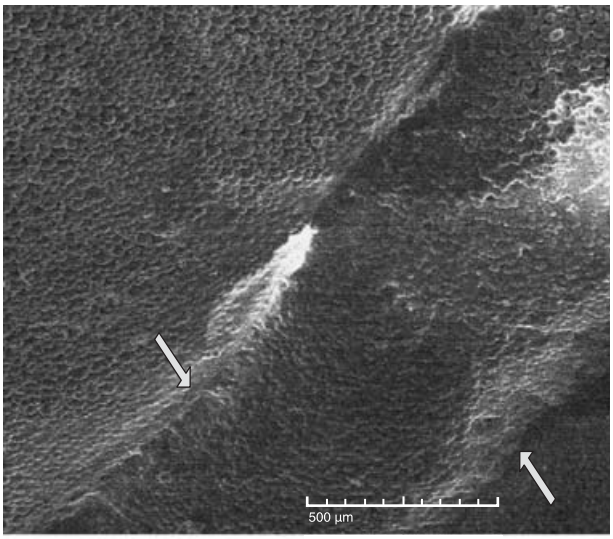


**Fig. 2.** Good marginal integrity of glass ionomer cement sealant.

The SEM analysis showed that fissures with a substantial loss of material do not have sufficient remnants of material in the fissure that could have preventive effect. However, the size of our study was too small to allow an analysis to address this question.

Figures 2–4 present SEM images of teeth: the intact seal of the sealant material to enamel tissue, the complete loss of GIC sealant, and the fracture of glass ionomer sealant in the fissure.

## Discussion

The results obtained in this study of resin sealant material, which served as a control group, are

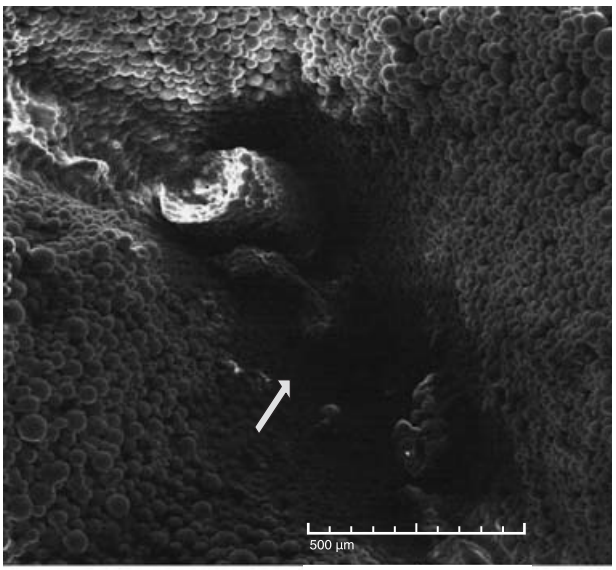


**Fig. 3.** Empty fissure after loss of glass ionomer cement sealant.

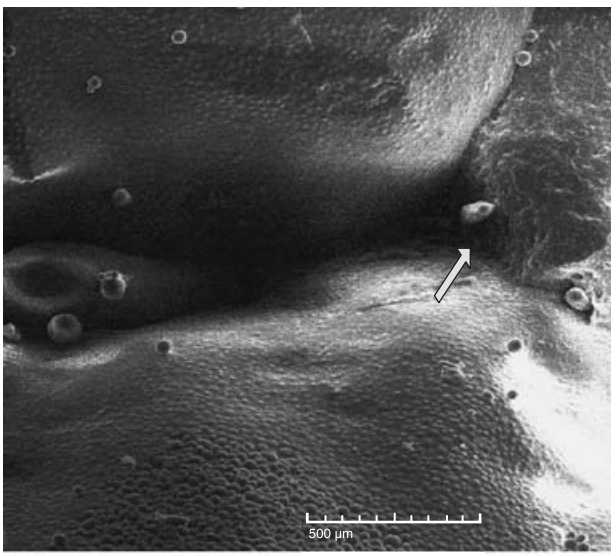


**Fig. 4.** Fracture of glass ionomer cement sealant in the fissure.

in agreement with other previously published results[19,25,26]. Glass ionomer materials show relatively low retention rate after 12 months. The obtained results were not different in comparison to the results published for classic

(chemically cured) glass ionomers[12,14–17,27]. Surface conditioning and heating do not have any influence on retention rate of the tested material (Fuji VII). Of particular interest is the 2-year Finnish study in which it was concluded that at the end of the clinical trial, full retention of polyalkenoate cement was determined on 26% of the sample compared with 82% of the Bis-GMA material[27]. After 28 months, Poulsen *et al.*[12] observed a complete retention rate of < 10% for a Fuji III, whereas Pardi *et al.*[14] observed a total retention rate of 3.5%. Weerheijm *et al.*[20] observed a total retention rate of 51% for Fuji IX and 15% for Fuji III after 9 months. In this study, the results of the incidence of new caries lesions in glass ionomer groups are not statistically significant.

The duration of the study was 1 year because of low retention rate of GIC sealant material. Despite of preferential chewing pattern that most of the patients chewing on the right side, the control sealant group (Helioseal F) showed very good retention rate of 80%.

Sidhu *et al.* tested the contraction of GIC material after heating. They concluded that the rate of contraction depends on the porosity of the GIC material[22]. Such dimensional changes of material could affect not only the marginal integrity of the material/enamel interface, but also the quality of adhesion between glass ionomer and enamel. Because the viscosity of glass ionomer material used for sealing is greater than that of the resin sealant material, McLean and Wilson proposed using glass ionomers only when the fissure diameter is more than 100 μm[6]. Also, solutions and gels used for topical fluoridation can attack the surface of glass ionomer materials, creating increased roughness[28]. This can provoke fracture in material and loss of retention.

It has been stated that remnants of GIC in the fissure system could have a preventive effect[18,20]. In this study, we could not establish sufficient remnants of GIC sealing material in the fissures. The improved cariostatic effects of GICs could be achieved through regular re-application, although this would considerably increase the unit costs of prevention. The Cochrane Review was unable to reach any conclusion by comparing glass ionomer fissure sealants and resin-based fissure sealants[29].

In conclusion, it could be said that the retention rate of glass ionomer sealants treated with heat was significantly lower than the retention of conventional composite resin sealants. The reduction in operating time and the adherence of these materials to moist teeth undoubtedly favour their placement on partially erupted molar teeth making it much easier to apply clinically. This could be especially relevant to high-risk caries patients and patients with special needs.

**What this paper adds**

- This paper adds more information concerning the usefulness of GICs as fissure sealants. Heat treatment of GIC during setting does not have an effect on retention rate.

**Why this paper is important to paediatric dentists**

- This paper is important because it shows that for prevention of occlusal caries, retention rate of material is crucial.
- This paper provides further data on retention rate and caries preventive effect of GIC and resin-based fissure sealants.

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