In Vitro Evaluation of Microleakage Under a Glass Ionomer Surface Protector Cement After Different Enamel Treatment Procedures

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Abstract
Aim: The aim of this *in vitro*study was to evaluate the microleakage of a glass-ionomer surface-protector cement (GC Fuji Triage) placed onto the fissure surfaces of extracted human molars prepared using six different treatment procedures. ***Methods:*** Ninety-six extracted non-carious human molar teeth were divided into five enamel treatment groups: (Gp1) air-abraded (Micadent II, Medidenta); (Gp2) air-abraded and conditioned with 10% polyacrylic acid (GC dentin conditioner); (Gp3) prepared by a bur designed for enameloplasty (#8833 Komet); (Gp4) prepared with a bur and conditioned; (Gp5) conditioned; and (Gp6) no treatment (control). The teeth were then sealed with GC Fuji Triage. The teeth were thermocycled and left in distilled water or artificial saliva for one week, coated twice with nail varnish, and stained in a dye. They were sectioned and scored for microleakage. ***Results:*** All groups showed microleakage. Samples that were kept in saliva had better results than those that were kept in distilled water ($P<0.05$). Samples conditioned before the treatment were also better than non-conditioned groups ($P<0.05$). In distilled water and artificial saliva, the range of the groups was, from the best, Gp2<Gp4<Gp5=Gp3<Gp1=Gp6 and Gp4<Gp2<Gp3<Gp5<Gp1<Gp6, respectively. ***Conclusions:***This *in vitro*study showed that the microleakage under the GIC material could be improved after treatment procedures such as conditioning, and/or air abrasion, and/or ameloplasty.

Key Words: Glass-Ionomer Cements, Fissure Sealant, Microleakage

Introduction

Resin-based pit and fissure sealants are effective caries-preventive agents as long as they remain bonded to the teeth [1]. These materials have been studied as fissure sealants since the 1960s and have shown high retention rates after different evaluation periods [2,3]. In the 1970s, glass-ionomer cement (GIC) was developed and is now widely used in restorative dentistry for a variety of purposes. Advantages over other restorative materials include restoration into cavities without any additional bonding procedure, an ability to release fluoride, and relative biocompatiblity with the pulp [4].

In a study by Boksman *et al.*(1987), the retention rate of GIC sealant after six months was only 2% for full retention, and the GIC sealant was totally absent in 94% of the samples [5]. Other authors reported 1.2% retention after five years [6] and 4% after three years [7] for glass ionomers used as sealants [8,9]. In a randomised controlled trial, Chadwick *et al.* (2005) found no evidence that the use of GIC sealant in the trial had any effect on caries incidence and stated that the glass ionomer could not be recommended as a clinical procedure [10-12]. The use of GIC has been suggested for erupting teeth where isolation is a problem, especially in high-caries risk individuals [13-15]. In this situation, they can be considered more of a fluoride-release vehicle than a traditional fissure sealant [16].

Studies have shown that the microleakage under resin-based materials could be improved after treatment procedures such as conditioning, and/or air abrasion, and/or ameloplasty [17-19]. Similar procedures may apply for GICs but to the authors knowledge, there have been no studies directly comparing the retention of GIC sealants after different preparation of pits and fissures for their degree of microleakage.

Fuji Triage is produced especially for fissure protection. It has been reported that major advantage of using Fuji Triage over other GICs is the fluoride release by the sealant, which is considered to be the highest among all GICs [20].

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Aim

The aim of this *in vitro* study was therefore to evaluate the microleakage of a glass-ionomer surface-protector cement (GC Fuji Triage) placed onto the fissure surfaces of extracted human molars prepared using six different treatment procedures.

Material and Methods

Ninety-six surgically removed impacted unerupted third molar teeth with intact occlusal surfaces were used in this study. The consent to use these teeth for research purposes was obtained from the patients. After extraction, the teeth were cleaned with pumice and tap water, examined for their occlusal surfaces, and stored in saline solution. They were randomly divided into six groups (16 teeth per group). The teeth in the six groups were prepared as described below.

In Group 1 (Gp1), eight teeth were air-abraded using 25 μm α-aluminium oxide particles in a Micadent II® machine (Medidenta International, New York, USA). Its properties have been described previously [1]. The pressure was set at 110 psi and the tip was held at least 10 mm from the tooth and angled toward the lingual surface. The surface was examined and the procedure was repeated when necessary. In Group 2 (Gp2), the teeth were air-abraded in the same manner using a Micadent II machine and then 10% polyacrylic acid (GC dentine conditioner) was applied for 20 seconds. The conditioner was washed away from the tooth surfaces using an air-water spray and air-dried for 10 seconds. In Group 3 (Gp3), the pits and fissures of eight teeth were prepared with a dimond fissure bur specially designed for preparing fissures (Komet #8833; Gebr. Brasseler, Lemgo, Germany) in a high-speed hand instrument. In Group 4 (Gp4), the fissures of eight teeth were prepared with a bur and 10% polyacrylic acid was then applied. In Group 5 (Gp5), 10% polyacrylic acid was applied to the teeth. In Group 6 (Gp6), the control group, GIC material was applied directly to the fissures, without any chemical or mechanical preparation.

The teeth in all of the groups were then sealed with GIC material inserted into the fissure using finger pressure. They were then coated with a varnish (GC Fuji Varnish). After sealing, all teeth were then thermocycled 500 times at temperatures of between 5°C and 55°C (extremes of cold and hot food and drink that materials might be exposed to *in vivo*). Half the teeth from each group were placed in distilled water and the other half in artificial saliva for one week. After this, they were dried and all surfaces, except for the sealed sections and an approximately 1 mm-wide band surrounding them, were coated twice with a nail varnish. The teeth were then immersed in a 2% buffered methylene blue solution for 24 hours at room temperature to allow dye penetration into possible gaps between the enamel and sealant. The teeth were then cross-sectioned in a bucco-lingual plane through the sealant and each section was examined under 4X magnification using a stereomicroscope. Dye penetration was evaluated according to a modified method described by Övrebö and Raadal (1990) [21]. Two examiners scored the specimens.

Examples of the scoring are illustrated in *Figures 1, 4, 5, 6* and *7*. The data were statistically analysed using the Kruskal Wallis analysis with the confidence level set at 99%.

Results

All groups showed some amount of microleakage (*Table 1, Figures 1-3*). Samples conditioned before the treatments were better than those in the non-conditioned groups (*P*=0.00366) (*Table 2, Figures 4, 5*). Samples kept in saliva also demonstrated better results than those in distilled water (*P*=0.000794) (*Table 3, Figures 6, 7*). In distilled water and artificial saliva the range of the groups was, from the best, Gp2<Gp4<Gp5=Gp3<Gp1=Gp6 and Gp4<Gp2<Gp3<Gp5<Gp1<Gp6, respectively.

Table 1. *Distribution of microleakage scores in each group*

Groups	1/3	2/3	3/3	Result
Gp1 (as)*	2	6	0	14
Gp1 (dw)†	6	2	0	10
Gp2 (as)	0	1	7	23
Gp2 (dw)	0	3	5	21
Gp3 (as)	0	2	6	22
Gp3 (dw)	4	3	1	13
Gp4 (as)	0	0	8	24
Gp4 (dw)	2	2	4	18
Gp5 (as)	0	3	5	21
Gp5 (dw)	4	3	1	13
Gp6 (as)	6	0	2	12
Gp6 (dw)	6	2	0	10

*Artificial saliva, †Distilled water

Table 2. *Microleakage scores of conditioned and non-conditioned groups*

	1/3	2/3	3/3	Result
Non-conditioned	24	15	9	81
Conditioned	6	12	30	120

(*P*=0.00366)

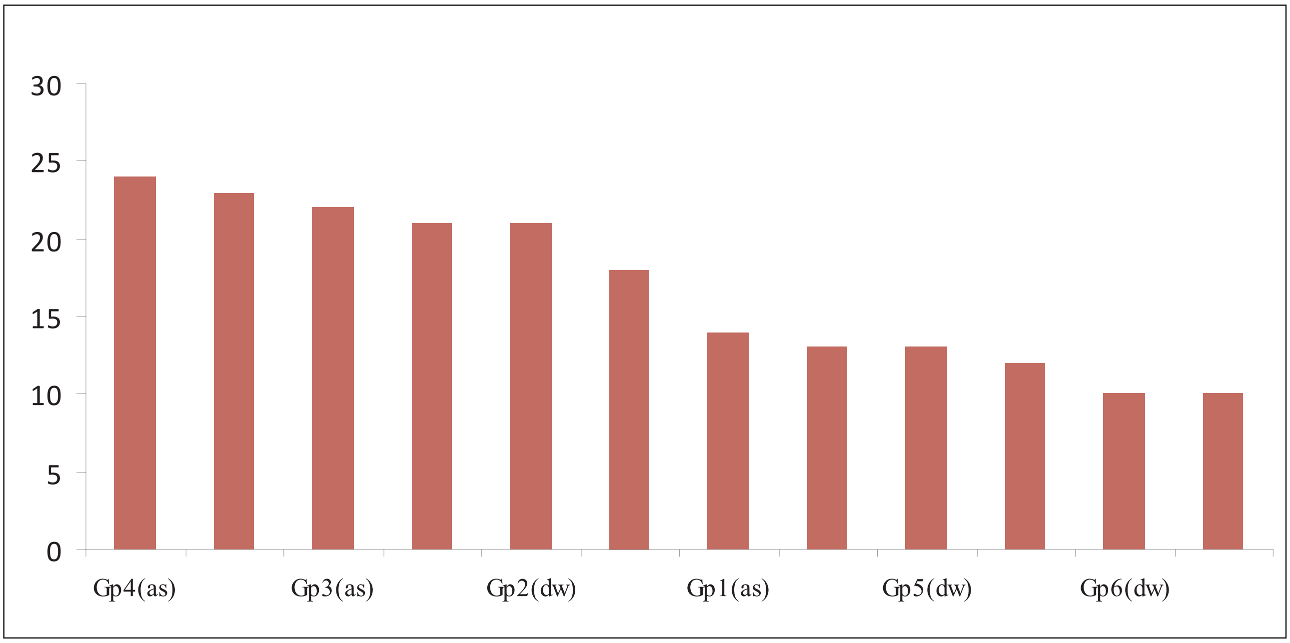

Figure 1. *Distribution of microleakage scores in each group*

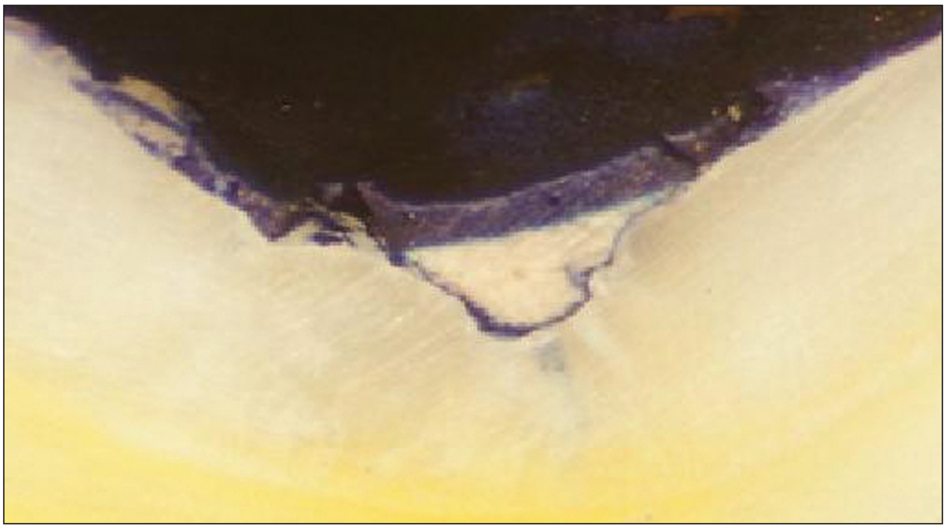

Figure 2. *Microleakage under the material.*

Table 3. *Microleakage scores of samples kept in artificial saliva and distilled water*

	1/3	2/3	3/3	Result
Artificial saliva	8	12	28	116
Distilled water	22	15	11	85

(*P*=0.000794)

Discussion

Some authors have considered that sealant integrity of the enamel–sealant interface reduced the mineral loss of the fissure to a considerable degree and established the caries decrease and efficacy of the sealant. The clinical success of sealants depended mostly on the ability of the material to bond firmly to the enamel and securely isolate these surfaces from the oral environment [22,23].

Conditioning of the tooth surface prior to the application of GICs has been reported to improve the bond strength [24,25]. In this *in vitro* study, there was microleakage in every sample regardless of whether the teeth were kept in distilled water or in saliva. Clearly, microleakage at the enamel–material interface was inevitable after the GIC application. However, samples kept in artificial saliva and conditioned before treatment exhibited significantly less microleakage.

Preparation of the specimens for this investigation may have led to some dehydration of the restorations, especially during application/drying of the nail varnish. Bouschlicher *et al.* (1996) showed that accidentally drying out a restoration prior to dye immersion increased microleakage scores for some resin-modified GICs, GICs, and

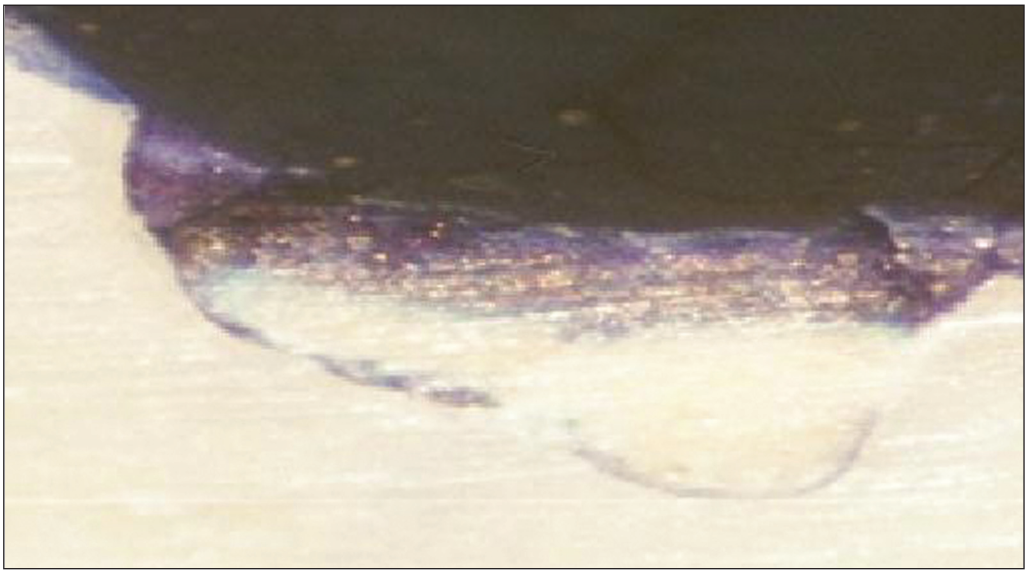

Figure 3. *Microleakage under the material.*

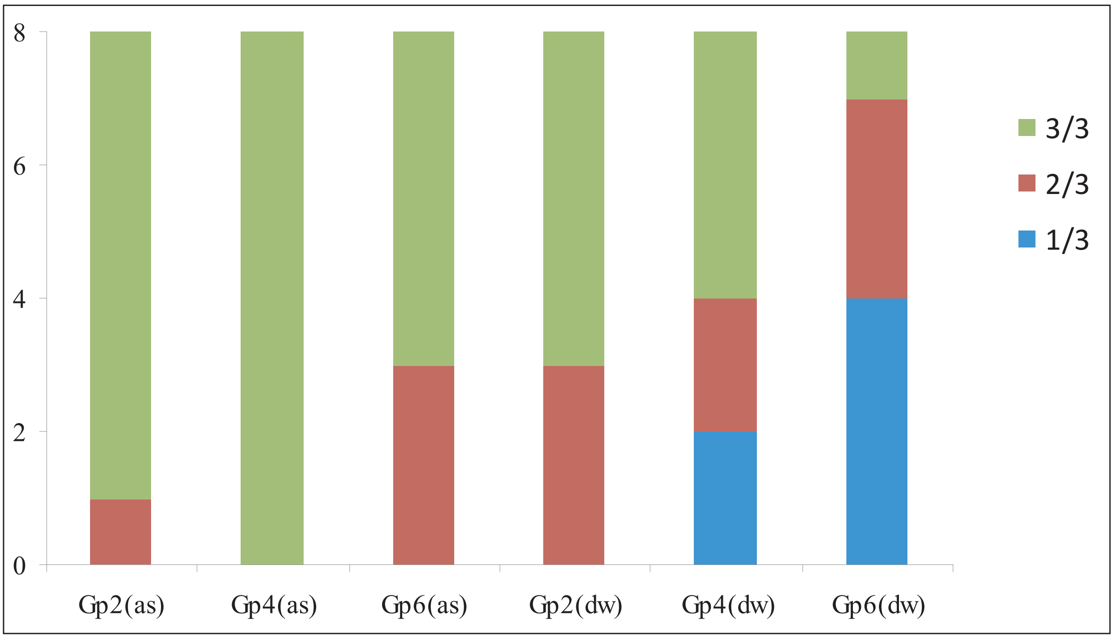

Figure 4. *Microleakage scores of conditioning groups*

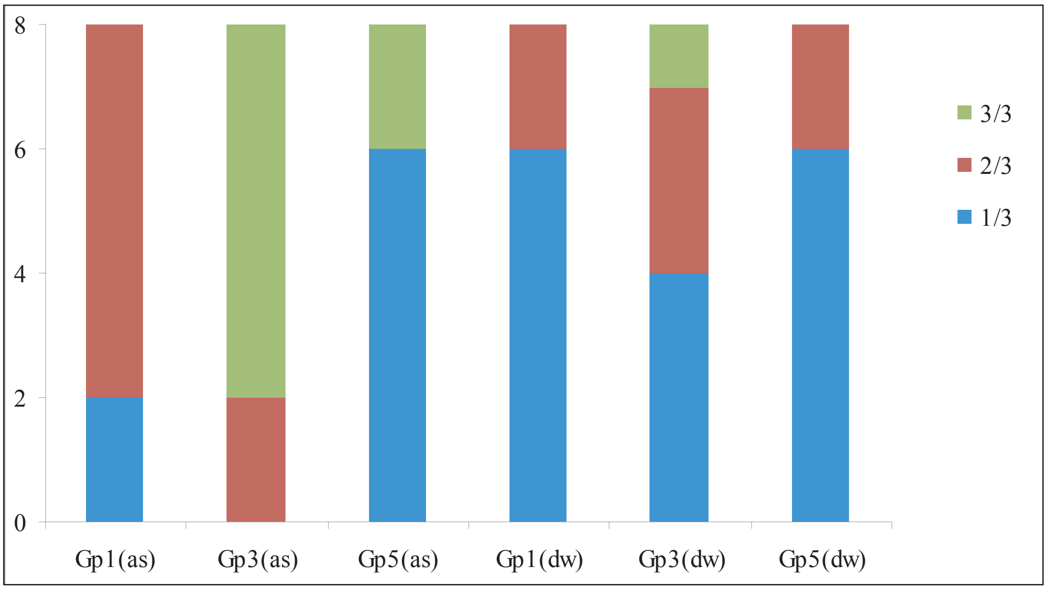

Figure 5. *Microleakage scores of non-conditioning groups*

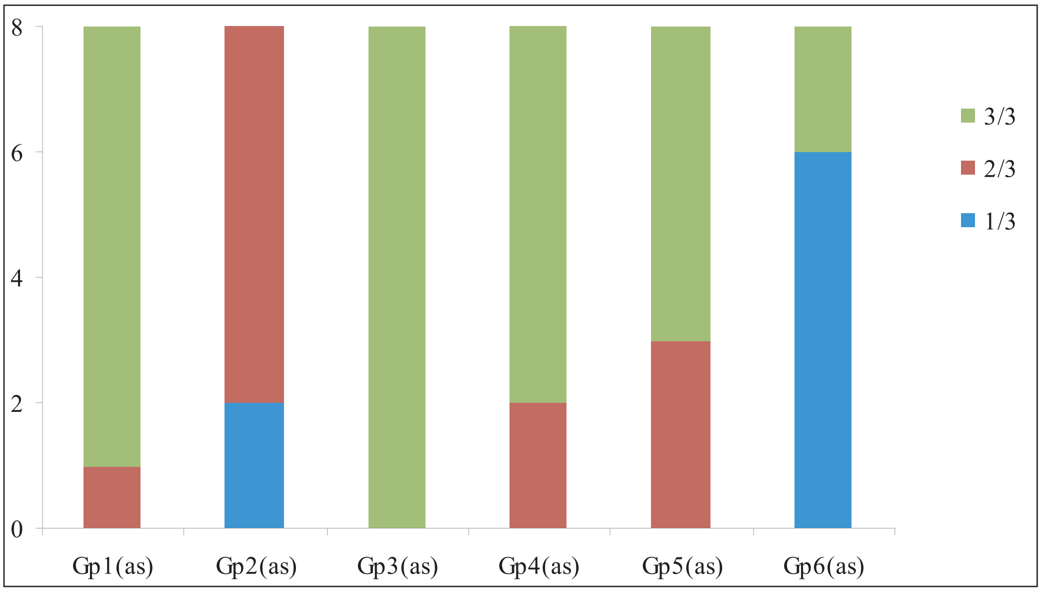

Figure 6. *Microleakage scores of samples kept in artificial saliva*

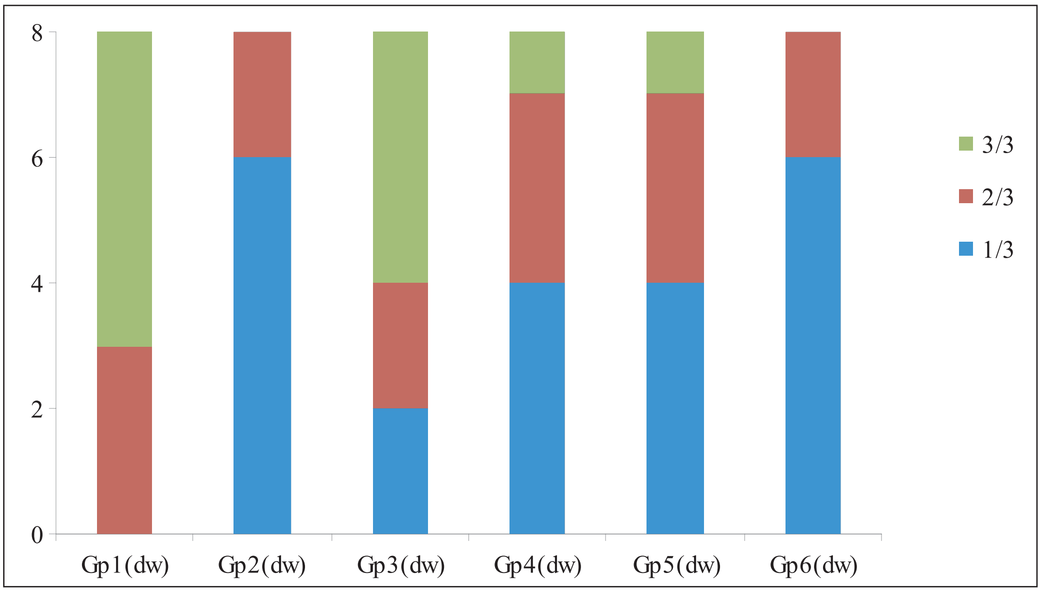

Figure 7. *Microleakage scores of samples kept in distilled water*

microfill resins. If contraction under desiccating conditions disrupts the bond at the cervical margin or is far greater than the expansion by water absorption, there could be a resulting increase in microleakage [26-28]. Freshly set GICs are sensitive to moisture and should be protected immediately with a waterproof varnish [26]. In this study, after the GIC material had been applied, all samples were coated with a varnish (GC Fuji Varnish).

One of the prime factors governing the efficacy and life expectancy of a sealant is the marginal adaptability. Many studies reported a better efficiency of sealant when using an invasive technique [29]. According to Herle *et al.* (2004), the invasive technique showed, both for GIC and resin-based sealant, better flow and adaptation to the fissures when compared with a non-invasive technique [20].

In the current study, different preparation techniques were used. However, the study has shown that fissure sealants placed after air-abrasion or preparation with a bur did not differ significantly with regard to microleakage. Air-abrasion with 10% polyacrylic acid resulted in less microleakage than the other methods of preparation; however, in the control group (in which GIC was applied directly to the fissures), it led to more microleakage than the other methods of preparation although this difference was not significant.

In the present study, all groups showed some degree of microleakage and it was noticed that, although cohesive failure was seen in all specimens, detachment of the sealant left a continuous quasi-layer of sealant covering the fissure enamel. The fracture of the sealant above this layer and cracks in this layer presumably could have occurred as a result of low cohesive strength and faulty preparation; namely, forces applied to the tooth during cutting and/or desiccation. The major reason for microleakage was due to some degree of disintegration of the sealant due to its solubility. Because GIC is hydrophilic, it has the tendency to absorb the dye into the material and this could give a false-positive result.

These findings were very similar to those described in a study by Herle *et al.* (2004) [20], wherein cohesive failure of the glass ionomer and fracture of the material was seen in all the specimens.

Hatibovic-Kofman *et al.* (2001) [17] reported that air abrasion with acid etching resulted in significantly less microleakage than the conventional and bur preparation. When air abrasion appeared on the market in the 1990s, it was claimed that it could prepare enamel surfaces for pit-and-fissure sealants in a manner similar to acid etching [30]. Hatibovic-Kofman *et al.* (1998) [18] reported that air abrasion without acid etching was similar to acid etching alone but inferior to bur preparations in its effect on microleakage. Other studies on microleakage have indicated that air abrasion alone does not provide the seal attained with acid etching only [1,18].

In vitro evaluation of dye penetration has frequently been used to test the sealing efficiency of restorative systems [31]. In a study by Rodrigues *et al.* (1999), it was seen that resin-modified GICs and polyacid-modified composite resins had microleakage patterns similar to a resin, but statistically different from a conventional GIC. However, some hybrid materials tested were not significantly different from a GIC that showed the higher microleakage median score [31].

GIC requires a prolonged maturation time and should not be challenged with dehydration within six months of placement [9].

GICs have been considered as an alternative, but they have always been looked down upon when they are used as pit-and-fissure sealants. This has been due to their poor physical properties. Considering the fact that the fluoride release by this product was supposed to be greater than the release of fluoride from any other glass ionomers, it may be a promising future pit-and-fissure sealant [32,33]. An *in vivo* study should be carried out to ascertain the longevity and cariostatic effect of GIC. Such an *in vivo* study is now being performed in the Paediatric Dentistry Department of the Dental School at Marmara University, Istanbul, Turkey.

Conclusion

This *in vitro* study showed that the microleakage under the GIC material could be reduced following treatment procedures such as enamel conditioning, and/or air abrasion, and/or ameloplasty.

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Contributions of each author

- EH performed the experimental part of this study.
- ARM and IT performed blind evaluation of microleakage under the stereo-microscope.

Statement of conflict of interest

As far as the authors are aware, there is no conflict of interests, other that that given in the Acknowledgment section of this paper.

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