

The Effect of Different Periods of Enamel Microabrasion on the Microleakage of Class V Glass-Ionomer Restorations

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Abstract

Objective: Removal of enamel superficial layer during microabrasion treatments may adversely affect sealing ability of the restorative materials. The aim of this study was to measure the effect of different periods of enamel microabrasion on the microleakage of class V glass-ionomer restorations.

Methods: This *in vitro* experimental study was conducted on 96 Class V cavities which had been prepared on the buccal and lingual surfaces of 48 sound human premolars. After conditioning with 10% polyacrylic acid (GC, Tokyo, Japan) one half of the cavities were restored with the conventional glass-ionomer (Fuji II GC, Tokyo, Japan) and another half with resin-modified glass-ionomer (Fuji II LC GC, Tokyo, Japan). Finishing and polishing were performed after 24 hours and the teeth incubated for 2 weeks (37°C and 100% humidity). Then the teeth were classified into eight groups (n=12). Microabrasion treatment was performed with Opulster (Ultradent product Inc, South Jordan, UT, USA) in 0(control no treatment), 60, 120 and 180 seconds. Then teeth were thermocycled between 5°C-55°C (×1000), immersed in 0.5% basic-fushin solution (24h) and sectioned longitudinally in bucco-lingual direction (n=192). Dye penetration was examined with stereomicroscope (×40). Microleakage scores were statistically analyzed by Kruskal-Wallis test while the paired comparisons were done using Mann-Whitney U test.

Results: The mean microleakage scores were significantly increased following increased microabrasion times in occlusal margin in FU II ($p<0.009$) and FU II LC ($p<0.02$) and in gingival margin in resin-modified glass-ionomer ($p<0.04$).

Conclusion: In Fuji II restorations after microabrasion in occlusal margins, microleakage increased up to 120s but in gingival margins no significant difference were seen. In Fuji II LC restorations after microabrasion in occlusal margin, microleakage from 60s up to 180s was significantly increased. In gingival margin with increasing the time up to 180s microleakage increased.

Key words: Enamel Microabrasion, Glass-ionomer, Microleakage

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Introduction:

Microabrasion is a well-known method for treatment of enamel surface discolorations such as enamel decalcifications or demineralization especially in dental fluorosis. In this technique, a thin layer of demineralized enamel is removed to improve the appearance of discolored teeth(1).

In microabrasion technique the discolored

enamel is removed by rubbing a mixture of an acid (HCl) and abrasive particles (pumice, silicon carbide) with a rubber cup, so the normal underlying enamel appears. Microabrasion technique permanently removes white-brown discolored enamel and leaves a compact layer of prism less enamel which has normal light reflection and luster. Finally the micro abraded enamel has a glass-like appearance like normal teeth(2). In many discolored teeth erosion,

abrasion or caries lesions may co-exist in cervical areas. These lesions should be restored before microabrasion(2)

Chan *et al.* (1996) showed that in exposed dentin surfaces approximately removed 50µm of dentin after 20 times five-second applications(3). Although acid cannot penetrate into pulp chamber penetration of acid into bared dentin may result in opening of dentinal tubules and hypersensitivity (4).

Glass- ionomer cements, one of the most versatile of the acid-base cements, with peculiar ability of adherence to enamel and dentin and fluoride release is known as the material of choice for restoration of cervical lesions (5). Despite these advantages these materials are vulnerable to dehydration and acid erosion which both of them may occur during rubbing microabrasion compound against the labial enamel (6). Scanning electron microscope (SEM) of glass-ionomer cement for 15 seconds with 37%orthophosphoric acid, showed removal of matrix and development of deep clefts between particles (7).Chan *et al.* (1996) evaluated the effect of microabrasion technique on dental materials and dental surfaces and showed that microabrasion increases surface roughness of glass-ionomer cements to the extent that may contraindicate its usage(3). They finally recommended that this technique must be used with caution in the presence of glass-ionomer restorations. In addition during microabrasion technique there is irreversible loss of enamel which may have adverse effects on sealing ability of restorations .Waggoner *et al.* (1989) measured the enamel loss after 10 times rubbing of 18%HCl and pumice. They showed that initially 12 micrometer of enamel was removed and after every sequential application there was 26 micrometer loss and after 10 times application about 25% of permanent canine enamel was removed (8).Tong *et al.* (1993) and Dalzell *et al.* (1995) showed different amounts of enamel loss after application of HCl-pumice

compound(9, 10). Since the erosive effect of HCl and enamel loss during microabrasion technique may adversely affect on sealing ability of glass-ionomer restorations, this experiment was held to measure microleakage of class v of glass-ionomer restorations with different periods of microabrasion.

Methods:

Forty eight sound human premolars extracted within 3 months for orthodontic purposes were selected. The teeth were hand-scaled, cleaned, and stored in distilled water containing 0.5% chloramine (23(2°C)) prior to use. Two standardized class v cavity preparations were placed on buccal and lingual surfaces of each tooth with a high-speed hand piece (96 cavities), using 008 cylindrical diamond bur (green code D+Z Germany) with copious water spray. The bur was changed after every five cavity preparations. The cavity dimensions were 3 (0.2) mm occluso-gingivally and 4 (0.2) mm mesiodistally, and 1.5 (0.2) mm in depth(10, 11). No bevel was placed. The cavity preparation was measured using a periodontal probe. The cervical margin of preparations located 1 mm under the cement-enamel junction and the occlusal margin located on enamel. Following cavity preparation and applying conditioner (10% polyacrylic acid (GC, Japan) for 10 seconds and rinsing for 20 seconds. Afterward standard powder/liquid ratio of the glass-ionomer cements were dispensed and mixed as specified by the manufacturer. The cavities were filled in single increment with a plastic instrument and immediately protected by a thin layer of enamel bonding resin (margin bond, Olten, Switzerland). Care was taken to prevent desiccation of the restoration surface. The Fuji II LC restorations were light-cured (40 seconds) using a Demetron Optilux 400 curing light unit (Kerr, Orange, CA, USA). The output of curing light monitored using a Demetron

radiometer (Kerr, Orange, CA, USA) to maintain more than 600mw/cm² light output. Then the specimens were stored in distilled water in incubator (37°C) for 24 hours. Then restorations were contoured and finished with 15 surgical blade and flame diamonds finishing burs (yellow coded, D+Z Germany) under water spray. Polishing was done with Sof-lex disks (3M ESPE) under water spray with low speed hand piece. After polishing, all of the specimens were stored in distilled water incubator at 37°C

and 100% humidity for 2 weeks. Therefore in each tooth the buccal surface was restored with Fu II (n=48) and lingual surface with Fu II LC (n= 48).

Microabrasion treatment was performed in experimental groups in 60, 120, 180 seconds periods. The microabrasion compound (Opalustre Ultradent) was applied on the surfaces of teeth and glass-ionomer restoration with a webbed rubber cup in different periods (Table 1).

Table 1- Materials used in this study

| Material | Manufacturer | Description | Composition |
|--------------------|--------------------------------|--|--|
| Fuji II | GC Corporation, Tokyo, Japan | Type II glass-ionomer cement | Powder: Alumino-fluoro-silicate glass (amorphous) Liquid: Distilled water, polyacrylic acid |
| Fuji II LC | GC Corporation, Tokyo, Japan | Type II resin modified glass-ionomer cement | Powder: Alumino-fluoro-silicate glass (amorphous) Liquid: polyacrylic acid, 2-hydroxymethylmethacrylate Acid: 6.6% HCl |
| Opalustre | Ultradent Products, Inc. USA | Chemical and mechanical enamel abrasion slurry | Abrasive: Silicon carbide pH=0.2 |
| Dentin conditioner | GC Corporation, Tokyo, Japan | | polyacrylic acid 10% Distilled water 90% |
| Margin bond | Oltten/ Whaledent, Switzerland | Light-cured, one component enamel abrasive | Methacrylate |

Depending on glass-ionomer type (Fu II, Fu II LC) and microabrasion time all the specimens divided into eight groups (n=12):

- 1-Fu II-0: GI filling (control without microabrasion)
- 2- Fu II LC-0: GI filling (control without microabrasion)
- 3-Fu II- 60: GI filling (60 seconds microabrasion)
- 4- Fu II LC- 60: GI filling (60 seconds microabrasion)
- 5- Fu II- 120: GI filling (120 seconds microabrasion)
- 6- Fu II LC- 120: GI filling (120 seconds microabrasion)
- 7- Fu II- 180: GI filling (180 seconds microabrasion)

8- Fu II LC- 180: GI filling (180 seconds microabrasion)

In groups that microabrasion done higher than 30 seconds, following each 30-sec application the teeth were rinsed with water for 10 seconds using air-water spray in order to provide similarity to clinical condition (11).

Microleakage evaluation:

After microabrasion all specimens were subjected to thermocycling regimen of 1000 cycles between 5°C and 55°C. Dwell time was 30 seconds within 10-second transfer time between baths.

In preparation for dye penetration test, the specimens were blotted dry with a paper towel, entirely sealed (incubation apical region) with epoxy resin and two coats of nail varnish were

applied to all surfaces of teeth except for 1mm adjacent to restoration margins. The teeth then were immersed in 0.5% fuchsin dye solution for 24 hours at room temperature. After immersion, the teeth were washed with running tap water for 30 seconds. Then the teeth were embedded in acrylic resin and sectioned longitudinally from the facial to lingual surface with a diamond saw with water-cooled diamond wheel saw (Isomet, Buehler, Lake Bluff, IL) (n=192).

To determine the degree of microleakage the occlusal and gingival margins of each section were examined with a stereomicroscope (Zeiss, Oberkochen, Germany) at X20 magnification by two independent evaluators. Both sides of specimen section were examined at the occlusal and gingival margins making a total two occlusal and two gingival microleakage scores

for each section. The following scoring system was used(12):

- 0= No penetration
- 1= Partial dye penetration along the occlusal or gingival wall
- 2=Dye penetration along the occlusal or gingival wall but not including the axial wall
- 3= Dye penetration to and along the axial wall

Statistical analysis was performed using the Kruskal-Wallis followed by Mann-Whitney U test with Bonferroni p-value adjustment. The difference between the occlusal and gingival dye penetration for each groups was analyzed by the Wilcoxon signed rank test.

Results:

Dye penetration scores for the occlusal and gingival margins were showed in Table 2.

Table 2-Microleakage distribution scores

| Occlusal (enamel) margin | | | | | | |
|---------------------------------|--------------|----------|----------|----------|--------------|---------------|
| Experimental group | Score | | | | | Median |
| | 0 | 1 | 2 | 3 | Total | |
| FU II 0 | 18 | 4 | 2 | 0 | 24 | 3 |
| FU II LC 0 | 17 | 5 | 2 | 0 | 24 | 3.5 |
| FU II 60 | 21 | 1 | 2 | 0 | 24 | 1.5 |
| FU II LC 60 | 12 | 5 | 5 | 2 | 24 | 5 |
| FU II 120 | 10 | 2 | 9 | 3 | 24 | 6 |
| FU II LC 120 | 13 | 7 | 4 | 0 | 24 | 6.5 |
| FU II 180 | 14 | 4 | 4 | 2 | 24 | 4 |
| FU II LC 180 | 7 | 5 | 9 | 3 | 24 | 6 |

| Gingival (dentin) margin | | | | | | |
|---------------------------------|--------------|----------|----------|----------|--------------|---------------|
| Experimental group | Score | | | | | Median |
| | 0 | 1 | 2 | 3 | Total | |
| FU II 0 | 18 | 2 | 3 | 1 | 24 | 2.5 |
| FU II LC 0 | 20 | 3 | 1 | 0 | 24 | 2 |
| FU II 60 | 21 | 2 | 0 | 1 | 24 | 1.5 |
| FU II LC 60 | 20 | 2 | 1 | 1 | 24 | 1.5 |
| FU II 120 | 20 | 2 | 2 | 0 | 24 | 2 |
| FU II LC 120 | 22 | 0 | 1 | 1 | 24 | 1 |
| FU II 180 | 16 | 3 | 4 | 1 | 24 | 3.5 |
| FU II LC 180 | 17 | 5 | 2 | 0 | 24 | 3.5 |

Within groups’ evaluation:

Fuji: Kruskal-Wallis one-way ANOVA indicated significant differences between groups for occlusal scores but in gingival margins differences were not significant. Mann-Whitney

test showed that in Fuji II Glass-ionomer groups at occlusal margin, microleakage scores increased significantly from 60 seconds to 120 seconds microabrasion ($p<0.009$). The microleakage scores in occlusal margins were

significantly higher than gingival margins ($p < 0.04$).

Fuji LC: Kruskal-Wallis one-way ANOVA indicated significant differences between groups for occlusal and gingival scores. Mann-Whitney test showed the most microleakage scores in enamel and gingival margins observed after 180_s microabrasion ($p < 0.02$ and $p < 0.04$ respectively). The microleakage scores in occlusal margins were significantly higher than gingival margins ($p < 0.0001$).

Between group's evaluation:

In comparison between two materials (Fuji and Fuji LC) no significant differences in microleakage scores of occlusal ($p < 0.77$) and gingival margins ($p < 0.08$) were observed. After 60_s and 180_s microabrasion, the microleakage scores in occlusal margins of Fuji LC groups were higher than Fu II groups ($p < 0.03$ and $p < 0.02$ respectively).

In gingival margins after different periods of microabrasion (0, 60, 120 and 180_s) no significant differences were observed between Fuji and Fuji LC groups ($p = 0.37$, $p = 0.17$, $p = 0.86$).

When comparing the occlusal and gingival scores for each groups, the Wilcoxon Rank test showed dye penetration was higher at occlusal margin than gingival margin statistically.

Discussion:

Enamel microabrasion is a chemical and micromechanical method by removing a microscopic layer of the enamel surface while eliminating superficial discolorations(2). In this technique, the chemical action produced by acid and mechanical action from the abrasive, will simultaneously erode and abrade the enamel surface(13). Matis *et al.* (1996) in a 10-year clinical study showed glass-ionomer restorations without mechanical retention had 80% retention rate(14). It has to be appreciated the glass-ionomer is an inorganic material and

predisposed to acid erosion(5). Conventional glass-ionomer materials suffer surface degradation—rapidly, especially in the presence of acidic foods(5). Acids directly attack the surface of glass-ionomer, causing the dissolution of the cement. The surface damage depends on the degree of acidity. When acids and wear mechanism operate simultaneously (similar to microabrasion) their influence is noticeable (15). Erosive and abrasive potential during microabrasion depends on several parameters, such as kind of acid, its concentration and pH, abrasive medium, time of instrumentation and the application mode (i.e. brushes, cups and bur and discs can be used as a slurry carriers) (16). In this study, these parameters were constant except of microabrasion time. The lowest microleakage score on enamel margins observed in control groups (without microabrasion) and there is significant difference between two types of materials were observed. Bonding by glass-ionomers is achieved by mechanical retention and chemical chelating(17).

Usually diffusion-based adhesion can be developed between the glass-ionomers and both enamel and dentin and this is unique to these materials(7). This adhesion is a dynamic phenomenon. The polymeric nature of glass-ionomer ensures a multiplicity of bonds between substrate and cement, under clinical condition, the scission of single bond does not lead to failure because the bond can reform(7). In enamel margins with increasing the microabrasion time in both glass-ionomers, the microleakage increased. This increase can be attributed to simultaneous effects of erosion and abrasive wear. In enamel surface after contact with an aggressive acid such as HCl, demineralization occurs. Scherer *et al.* (1991) in SEM analyses observed a slight etch or roughening of the enamel surface with rod peripheries appearing prominent at the 5-second application with the enamel microabrasion compound (18). Tong *et al.* (1993) reported that

18% HCl combined with pumice and rotary prophylaxis cups removed up to 360 μ of enamel and the effect was time dependent(9). In initial stage of contact with an acid, hydrogen ions (H⁺) attack on the matrix of glass-ionomer cement. Removal of some of the cross-linking metal ions does not lead to the disruption of the structure, because sufficient ions remain to connect the covalent polyacid chains(19). When the set cement contacts with acids, there are two aspects to be considered:

The leaching of soluble constituents from the cement and actual erosion. The loss of soluble species from the cement can lead to disintegration if they are matrix former, but if they are not, then this will have no effect on durability(19).

Fuji LC restoration in occlusal margins, after 60 and 180s microabrasion, showed higher microleakage than Fuji restorations ($p<0.03$ and $p<0.02$ respectively). In gingival margins, no significant differences were observed between Fuji and Fuji LC groups ($p=0.37$, $p=0.17$, $p=0.86$). Another important aspect that must be taken into account is the polymerization shrinkage of the resinous restorative material.

It is known that the resultant stress of polymerization shrinkage of resin can generate tensions between the restorative material and tooth substrate, which, consequently, can generate gaps in the adhesive interface(20).

The findings of this study cannot be compared to those of other studies due to lack of available data from researches using similar methodologies. In most studies the wear of glass-ionomers measured after mechanical loading and the simultaneous erosive and abrasive wear not measured(21, 22).

De Gee *et al.* (1996) evaluated the early and long term wear of conventional and resin-modified glass-ionomers. They showed that the wear of resin modified glass-ionomer appears to be significantly higher than that of conventional material, probably due to differences in matrix

formation. The matrix of conventional glass-ionomers consists of an ionically cross-linked polyalkenoate network resulting from an acid-base reaction. The set cement of Fuji II LC has similar cross-linked polyalkenoate networks, but these are entangled with HEMA polymer chains probably, the coherence of filler particles embedded in the penetrating matrices of polyacrylate and polymer is inferior to those particles in the conventional matrix. This may be due to partial replacement of the rigid polyalkenoate network by the flexible polymer chains(6, 23).

After microabrasion both types of glass-ionomers showed higher microleakage in occlusal than gingival margins.

These findings are in contrast with other glass-ionomers studies, most of them showed that microleakage in enamel margins were less than gingival margins(24, 25). But Ajami *et al.* (2007) compared microleakage between glass-ionomer and compoglass. they reported in glass-ionomer restorations microleakage in occlusal margins was higher than gingival margins.

As a result, polymerization shrinkage was noticed to be further accompanied by higher microleakage in the gingival margin but chemical bonding of glass-ionomers is an advantage in situations where it is difficult or impossible to produce micro-mechanical retention(17).

Chan *et al.* applied the Prema microabrasion compound on the flattened buccal surface of the human molar and central incisors for 20 times in 5-second periods. The loss of dentin estimated was approximately 50 μ after 20 applications. This is much smaller than that of enamel loss previously reported(3). Waggoner *et al.* (1989) reported that up to 25% of the labial enamel lost during microabrasion(8).

The human premolar in labial surface has a natural curvature (height of contour). It is very possible that the amount of enamel loss higher than dentin. In other words the microabrasive

material in enamel margins inadvertently more compressed(3).

Conclusion:

Under the limits and conditions of this study the following results were obtained:

The least microleakage scores were observed in occlusal margins of control groups (without microabrasion). And in both glass-ionomers the microleakage scores in occlusal margins were higher than gingival margins and in gingival margins both glass-ionomers had the same microleakage scores.

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