Adhesiveness of Various Glass Ionomer Cements in Cavities Treated with Carisolv

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Objective: *The purpose of this study was to investigate the adhesion of glass ionomer cements to dentin and the effect of pretreatment using Carisolv.* ***Study design:*** *Forty extracted permanent teeth with caries were used for this study. All lesions were removed using the Carisolv system and teeth were divided into eight groups. Groups 1 to 4 were filled with three types of conventional glass ionomer cements and a resin modified glass ionomer cement. Group 8 was restored with composite resin. In the remaining three groups (Groups 5 to 7), several pretreatment procedures, including EDTA and dentin primer application and a combination of these, were performed before restoring with resin modified glass ionomer cement. All restorations were thermocycled, and microleakage tests were performed on all teeth.* ***Results:*** *There were no statistical differences among Groups 1, 2 and 3 or between Groups 4 and 8. However, Groups 1 to 3 had higher microleakage levels than Groups 4 and 8. Groups 5 to 7 showed similar leakage levels as Group 4.* ***Conclusion:*** *Pretreatment with EDTA or dentin primer did not improve bonding ability. Combination of caries removal using Carisolv and a resin modified glass ionomer cement restoration without pretreatment seems to be an acceptable method for caries treatment.*

Keywords: *Glass ionomer cement, resin modified glass ionomer cement, Carisolv, microleakage test*

INTRODUCTION

Among the factors that influence the quality of dental treatment, caries removal techniques with less stress and pain play an important role. New caries removal systems such as laser,[1-3] air abrasion[4-6] and chemo-mechanical methods[7-9] have been reported as an alternative for the conventional method using rotary instruments. Carisolv is a chemo-mechanical caries removal system that uses sodium hypochlorite (NaOCl) and three types of amino acids (glutamic acid, leucine, and lysine). Glass ionomer restorations have been placed after Carisolv treatment.[10-12] However, the adhesion of glass ionomer to dentin surface after Carisolv treatment has not been investigated.

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In clinical situations, after removal of carious dentin, cavities are mostly restored with dental materials such as composite resins. In deep cavities, glass ionomer cement is used as a base for composite resin, since it is non-toxic to the pulp. Some types of glass ionomers release fluoride. Furthermore, glass ionomers require fewer steps for restoration compared to composite resin, which requires etching and bonding procedures. Thus, the use of this restorative material also reduces chair time, which is beneficial for patients who are afraid of dental treatment, especially small children. However, the efficiency of glass ionomer cement with chemo-mechanical caries removal treatment has not been analyzed.

The purpose of this paper was to investigate the adhesion of glass ionomer cement to dentin surface after caries removal by Carisolv treatment. Several types of glass ionomer cements were investigated and the effect of pretreatment before glass ionomer cement restoration was also evaluated.

MATERIALS AND METHOD

Preparation of Samples

Forty human permanent teeth (upper and lower premolar and molars) with caries at the buccal cervical portion, which were extracted for periodontal reasons with the consent of the patients, were used in the study. All specimens had similar caries characteristics for extent size, color, ,hardness. and depth. Moreover, the extent of carious lesions was further assessed by mean of KaVo DIAGNOdent 2095(Kavo Dental Gmbh,Jena, Germany). The criteria suggested Lussi *et al* was followed[13] Obtained number 0-13 (no caries),over 14 (Deep caries into the enamel or into the dentin). Carious lesions that scored higher than 14 with DIAGNOdent were used for this study. Teeth that met the inclusion criteria were

Table 1. Cavity treatment for each groups

Group	Pretreatment	Restoration materials
1	non	Fuji Type I cement
2	non	Fuji Type II cement
3	non	Fuji Type IX cement
4	non	Ionotite F
5	3%EDTA(1minute)	Ionotite F
6	dentin priming	Ionotite F
7	3%EDTA and dentin priming	Ionotite F
8	etching, priming, bonding	MAJESTY

were brushed and washed with distilled water and stored at room temperature.

The carious lesions in all teeth were removed by the Carisolv system (Medi Team Dental, Gothenburg, Sweden) following manufacturer´s instructions. The Carisolv gel used in this study was supplied as two separate components. Prior to use, they were mixed in a container and applied to the carious lesion for 30 seconds. Then the gentle excavating was performed using special hand instruments for Carisolv system.[8]

After complete carious dentin removal, cavities were rinsed with water spray. The caries removal was verified by three clinicians, using a caries-detecting dye (Caries check; Nishika, Yamaguchi, Japan) and DIAGNOdent with a reading lower than 13.

Teeth were randomly divided into eight groups (five teeth each) and the cavities were gently washed and filled with different restorative materials. The teeth in Groups 1 to 3 were filled with three types of conventional glass ionomer Conventional GICs) (Group 1, Fuji type I cement; Group 2, Fuji type II cement; and Group 3, Fuji type IX cement; GC Co. Ltd., Tokyo, Japan). Group 4 was restored by resin modified glass ionomer cement (Ionotite F, Tokyuyama Inc., Kurashiki, Japan). These four groups had no pretreatment prior the application of a glass ionomer cement. The cavities in Group 5 received a 3% EDTA (Smear clean, Nishika Co. Ltd., Tokyo, Japan) for 1 minute, washed with a water spray and restored with Ionotite F. The cavities in Group 6 were treated with a dentin primer (Inperva™ Bond, Shofu Inc., Kyoto, Japan) for 20 seconds, air-dried for 10 seconds and restored with Ionotite F. Group 7 underwent a combination of the procedures in Groups 5 and 6, comprising EDTA application of the cavity surface, washing, dentin priming and restoration with resin modified glass ionomer cement (Ionotite F). Group 8 was acid-etched for 15 seconds and washed for 5 seconds. Then they were primed (Mega Bond FA, Kuraray Co., Kurashiki, Japan) for 20 seconds. After bonding and light cured for 10 seconds. Finally they were restored with composite resin (MAJESTY, Kuraray Co., Kurashiki, Japan) and light cured for 30 seconds following manufacturer's instructions. Table 1.

Microleakage Test

The teeth in each group were subjected to a microleakage test. The microleakage test was performed according to a previous study.[14] All tooth surfaces except the areas of the restored cavities and 1 mm outside the margins of the cavities were double-coated with nail varnish. The samples were thermocycled for 1000 cycles between 5°C (± 2) and 55°C (± 2) with a 1-min dwell time in each temperature, and immersed for 12 h in a rhodamine-buffered dye solution. They were transversely bisected with a diamond saw disc (Isomet, Buehler, IL, USA). The degree of microleakage was scored in a blinded manner using dye penetration, based on a modification of a previously reported 4 grade-scale criteria (Table 2) under a stereoscopic microscope by a technician who was not informed of the true nature and purpose of this experiment. Where scores showed different dye penetration within the same tooth, the worst score was used for evaluation.

Table 2. Scoring grade of microleakage test

Grade number	Content
0	No penetration
1	Penetrate only in surrounding enamel
2	Penetrate into dentin
3	Penetrate into cavity floor

Statistical analysis of the data was performed using Mann-Whitney U test and a value of $p < 0.05$ was considered significant.

RESULTS

The result of microleakage associated with each restorative material is shown in Table 3. All the three conventional GIC groups (Group 1 to 3) showed similar microleakage level. Complete microleakage (score 3) was observed in 3 specimen (60%) of *Group1 and 2* specimen (40%) in *Group 2 and 3* (Figure1-a). No leakage (score 0) was shown in all three groups (Figure1-b). Although there were no statistically significant differences among them, the three conventional GIC groups had significantly higher leakage levels than RMGIC and composite resin. The leakage level in *Group 4* (RMGIC group) was higher than that in *Group 8* (composite resin group). Leakage in *Group 4* indicated score 0 in 2 specimen (40%) and score 1 were 3 specimen (60%), while in *Group 8* score 0 was found in 3 specimen (60%) and score1 were 2 specimen (40%). There were no significant statistical differences between these two groups. The evaluation of the effect of pretreatment using EDTA conditioning or dentin primer application is also shown in Table 2. The microleakage in *Group 5* (EDTA-conditioned group) scored 0 in 2 specimens (40%), 2 specimens scored 2(40%) and 1 specimen scored 3 (20%). No statistical difference was shown when compared to *Group 4* (non pretreatment group).

Microleakage in *Group 6* (dentin primer application) was shown as followed score 0 was 3 specimen (60%) and score 1 was 2 specimen (40%). And the microleakage tendency was slightly lower than that in *Group 4*. However, no significant statistical differences were detected between the two groups. *Group 7* that was the combination of pretreatment with EDTA conditioning and dentin primer application indicated that 4 specimen of score 0(80%) and 1 specimen of score 1(20%).This group also showed the microleakage level was slightly lower than that in *Group 4* to *6* and *8*. However, no significant statistical differences were detected both *5* groups (*Group 4* to *8*).

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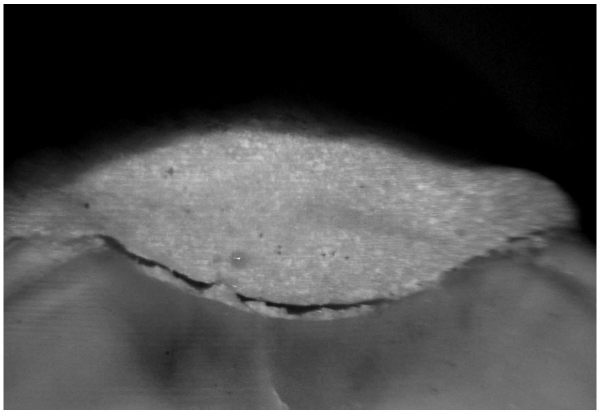

Figure 1a.

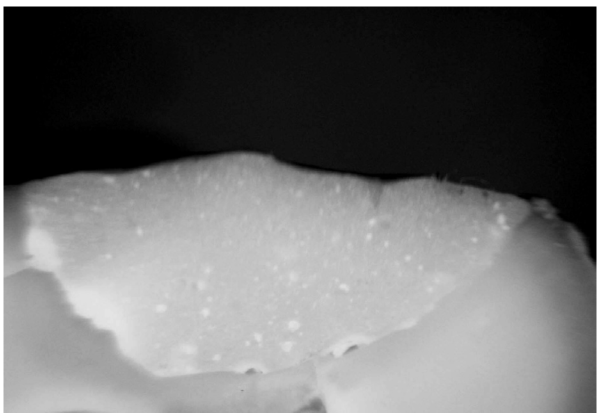

Figure 1b.

Table 3. Comparing the microleakage level in each restoration materials

Group	0	1	2	3	(mean±SD)
1(n=5)	0	0	2	3	2.50±0.50[a]
2(n=5)	0	0	3	2	2.25±0.43[b]
3(n=5)	0	1	2	2	2.00±0.70[c]
4(n=5)	2	3	0	0	0.75±0.43[d]
5(n=5)	2	0	2	1	1.75±1.08[e]
6(n=5)	3	2	0	0	0.50±0.33[f]
7(n=5)	4	1	0	0	0.22±0.35[g]
8(n=5)	3	2	0	0	0.25±0.43[h]

[a-c] No significant differences (P>0.05)
[d-h] No significant differences (P>0.05)
Statistical significant differences both a-c and d-f (P<0.05)

DISCUSSION

Several previous studies have reported that the affection for the quality of the restoration after caries removal by the chemo-mechanical method. At the beginning, this method was seemed to have an advantage for the restoration. Because the cavity surface after chemo-mechanical caries treatment were shown surface roughness than conventional treatment using burr and Chemo-mechanically treated dentin has a higher surface energy than conventionally treated dentin. This implies that chemo-mechanically treated dentin may have a greater affinity for adhesive materials and better bonding than conventionally treated dentin.[15] However other several researchers demonstrated that the bond strength of Carisolv treatment showed almost similar level compared with conventional bur treatment, and chemo-mechanical caries removal has not both adverse effect and interfered effect on adhesion to dentin.[16,17] It indicated that the chemo-mechanical caries removal method did not affect the quality of the restoration[18,19] and it means the restoration materials and restoration method have an important factor to obtain good result of the restoration.

After caries removal, cavities are usually restored with composite resins and the results were good in many studies. However, occasionally it is difficult to apply composite resin restorations, especially in small children who are afraid of dental treatment and the patients with dental phobia even adult patient. In such conditions, it seems to be difficult to establish sufficient treatment times. Therefore glass ionomer cement restorations are used to restore the cavities, since they do not require complex procedures such as etching and bonding. Thus, GIC restoration is a simple process requiring less treatment time compared to composite resin restoration. GIC restoration may be a high advantageous method for treating small children and the patients with dental phobia.

GIC was introduced by Wilson and Kent in 1972.[20] In dentistry, it is used as a restorative material and as a luting agent. The setting of GIC occurs as a reaction between silicate glass powder and polyalkenoic acid. Glass ionomer cements can chemically bond to dentine and enamel during the setting process. The mechanism of bonding appears to involve an ionic interaction with calcium and/or phosphate ions from the surface of enamel or dentine. Bonding is more effective on a clean surface, provided cleaning does not remove excessive amounts of calcium ions. Even though bonding strength and esthetic properties are inferior to composite resins, GICs have several advantages over composite resin. The advantages of GICs include inherent adhesion to tooth structure, simple application process, little shrinkage, good marginal seal, fluoride release and an anticariogenic effect. Clinically, GIC does not require etching of the cavity surface, which largely reduces the risk of damage to the dental pulp. Moreover, the property of releasing fluoride from GIC has a caries preventive effect as it enhances remineralization and inhibits demineralization of dentine,[21] consequently reducing secondary caries adjacent to the GIC restoration.[22] GIC is the only cement that is capable of releasing fluoride, which makes it unique among other cements and composite resins.

Although GIC restoration has the above-mentioned outstanding characteristics, none of the conventional GICs (Fuji type I cement, Fuji type II cement, Fuji type IX cement,) showed good results with the microleakage test in the present study. This can be explained by the fact that GIC is water-sensitive during the cement setting phase, and the weakness of GIC may reduce the bond strength to both the cement itself and the tooth substrate. Mount *et al*. reported that conventional GICs were sensitive to moisture contamination for up to 24 h.[23] Conventional GIC has a slow rate of cement setting, making it more susceptible to moisture contamination or dehydra-

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tion during the early stages of setting; therefore, GIC has low fracture toughness and poor resistance to leakage.[24,25] In this study, the three conventional GICs were exposed to moisture before complete setting, resulting in a weak bond strength. Thus, microleakage was observed along the margins of the GIC restoration. However, Ionotite F (RMGIC) restorations exhibited better microleakage resistance. RMGICs were introduced in the late 1980s and they combine the characteristics of composite resins and glass ionomer cements. The physical and mechanical properties are similar to those of composite resin. This cement has dual setting reactions such as the acid-base reaction of the conventional glass ionomer cement and the polymerization of resin monomer. RMGIC also possesses the fluoride releasing ability of conventional GIC.[26] Researchers have reported that the bonding strength of RMGIC was significantly higher than that of conventional GIC.[26,27] Ionotite F contains calcium phosphates with calcium alumino silicate glass, silica and benzoyl peroxide in the powder, and 2-hydroxyethyl methacrylate (HEMA), 1,6-bis(-methacryloxy-2-ethoxycarbonylamino)-2,4,4-trimethylhexane (UDMA), acid monomer MTU in the liquid. HEMA in RMGIC penetrates into dentin, creating dentin tags and then, a hybrid layer is formed.[28] In this study, the responsibility for lesser microleakage in RMGIC restoration group may not influence on the Carisolv treatment. It should be relayed on the several priming reagent like as HEMA and UDMA.

Previous studies demonstrated that pretreatment by EDTA conditioning was a contributing factor for the strong adhesive effect between both enamel and dentin and composite resin.[29,30] Fagundes *et al*. reported that EDTA pretreatment of dentin increased the bond strength of RMGIC to dentin, and improved the resistance to degradation of the bond between RMGIC and dentin.[31] Nakanuma *et al*. also suggested that bond strength was increased by EDTA pretreatment.[32] On the other hand, Brännström *et al*. observed no significant difference in gap formation between cavities cleaned with water or with a detergent containing 0.2% EDTA, and they concluded that the cavity cleaning procedure was not a significant factor in gap formation.[33] Our results were in agreement with Brännström *et al's* findings. It was suggested that the bond strength increased mainly because the resin monomer (HEMA) penetrated into the dental tubules, thus creating micromechanical retention and removal of the smear layer improved the adhesion.[31,34-36] EDTA application for 1 min as performed in this study might not be enough to remove the smear layer completely and hence the difference in microleakage with EDTA and without EDTA might not be observed clearly. It may be assumed that EDTA application for 1 min might not improve the bond strength in a cavity treated by the chemo-mechanical method. The affectability of EDTA might relay on the application time and EDTA concentration. The condition of EDTA solution which was used in this study should not enough concentration in one minutes application. Therefore it may improve the result if prolong the EDTA application time or rising of the EDTA concentration.

Application of Inperva Bond™ to the cavity before restoration with Ionotite F showed slight improvement in the leakage resistance. Inperva Bond™ is an adhesive monomer which contains HEMA. The improvement in leakage resistance is mainly attributable to the presence of HEMA. HEMA has hydrophilic action towards dental tissues and hydrophobic action towards resin. These characteristics of HEMA produce a moist environment which penetrates the collagen network, thus increasing the bonding force. Although Ionotite F contains HEMA, the concentration of HEMA in Ionotite F may not be enough to provide hardness and improved marginal seal. Application of HEMA twice during dentin priming and RMGIC filling may help to obtain an improved bond strength and marginal seal. Munksgaard *et al*. reported that bond strength was highly dependent on the HEMA concentration,[37] and their report supported the results of this study. Process of additional HEMA pretreatment caused rising of HEMA concentration, consequently it may induced improving adhesive ability both dentin and Ionotyto F.

However, some researchers reported that HEMA induced allergic reactions[38] and caused inflammation.[39] Therefore, even though additional pretreatment with dentin primers improved the marginal bond strength, HEMA should not be used as a pretreatment in cavities in children due to safety issues.

According to our study, combining chemo-mechanical caries removal method (Carisolv) and RMGIC restoration yielded good results and seems to be an effective method to treat caries in patients who are afraid of complex dental procedures. However, this study model may not simulate real oral conditions. Therefore, there is a possibility that conventional GIC is more stable in the oral cavity than reported in this study model. After placement of conventional GICs, large amount of fluoride release occurred during the first 24 to 48 h, followed by a rapid decline.[40] However, fluoride release continued for a long period, and release rates at 5 years have been found to be the same as the release rate measured at 5 months.[41] This indicates that the effect of released fluoride was kept maintained, thus the effect of fluoride as a prevention of occurring secondary caries by causing demineralization of enamel and dentin. Consequently the negative factor to inhibit bond strength between enamel/dentin and restorations, then it was a possible to occur the resistance of weakness of GIC and reduce bond strength.

In addition, Okada *et al*. reported that the Vickers hardness number of conventional GIC increased remarkably after 40 days of storage in saliva and reached the levels of composite resin, probably due to the interaction with the Ca and P in saliva.[42] Additional research to assess this finding is required.

In this study, RMGIC restoration of cavities after chemo-mechanical caries removal technique gave comparable bond strengths as composite resin restorations. Moreover, RMGIC restoration was simpler with fewer clinical procedures than composite resin restoration. Therefore, RMGIC restoration can be considered as a good candidate for patients who are afraid of complex dental treatments, such as small children. However, composite resin is generally preferred over glass ionomer cements for routine restorative procedures after caries treatment due to its superior physical properties. The combination method described here may be applied for restoration in suitable cases, based on the operator's discretion.

CONCLUSION

In this study of cavities prepared with Carisolv™, conventional GICs exhibited weak microleakage resistance. However, RMGIC restorations exhibited similar microleakage resistance as resin restorations. Pretreatment with EDTA and dentin primer application did not produce any significant change in microleakage. Therefore, the combination of chemo-mechanical caries treatment and RMGIC restoration without pretreatment method seems to be an acceptable treatment option for patients afraid of complex dental treatment.

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