Original Article

Effect of Finishing and Polishing Time, Technique and Surface Coating on Microleakage of Encapsulated Restorative Resin Modified Glass Ionomer: An In Vitro Study

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Abstract

Background and Aim: This study aimed to assess the effect of finishing and polishing time, technique and surface coating on microleakage of encapsulated restorative resin modified glass ionomer (RMGI).

Materials and Methods: In this in vitro study, 40 freshly extracted human premolars were selected. Two standard class V cavities were prepared on the buccal and lingual surfaces of each tooth. The prepared teeth were randomly assigned to eight experimental groups (n=10) according to the finishing and polishing time, technique and surface coating. The samples were blindly examined for marginal microleakage using a stereomicroscope at x40 magnification. The Mann-Whitney U test was used to analyze the obtained data with the level of significance set at P<0.05.

Results: Groups with surface coating showed significantly lower microleakage than uncoated samples (P<0.001). The groups in which discs were used had lower microleakage (P<0.001). There were no statistically significant differences between the groups with delayed or immediate finishing and polishing (P>0.05). Our results showed that there were no statistically significant differences between enamel and dentinal walls with regard to marginal microleakage scores (P>0.05).

Conclusion: Immediate finishing and polishing of coated restorations with Sof-Lex discs decreases their marginal microleakage. Also, it is more effective at the gingival margin.

Key Words: Dental Marginal Adaptation, Dental Polishing, Glass Ionomer Cements, Dental Leakage

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Introduction

Microleakage is one of the most important factors in cervical restorations (1). Microleakage can result in breakdown of the margins of restorations, leading to development of secondary caries at the tooth/restoration interface, postoperative tooth hypersensitivity and pulpal pathologies (2). When the restoration margins are in the gingival region below the cementoenamel junction, it is hard to seal them properly (3,4).

Glass ionomer cements are recommended for use in gingival restorations to decrease microleakage at the interface due to their

chemical bonding to tooth structure (5,6). Resin modified glass ionomers (RMGIs) are a modified form of glass ionomers which are manufactured by adding methacrylate groups to their chemical structure (7). This led to a reduction in brittleness and moisture sensitivity of conventional glass ionomers, and an increase in bond strength to the tooth structure (7,8). The powder in RMGI cements is a combination of an ion-leachable glass and a liquid, which has 4 essential components: A methacrylate resin, a polyacid, hydroxyethyl methacrylate and water, which is necessary for acid-base reactions (8). Additional photo-polymerization or adding more resin monomer cannot significantly overcome the dehydration problems of RMGIs. Thus, it is important to maintain the water balance in the cement (9). The importance of surface coating for RMGIs has been previously emphasized. Kitayama et al. (10) proved that resin coating significantly decreased microleakage. Another study by Miyazaki et al. (11) showed the effectiveness of surface coating on flexural strength of RMGIs. These studies indicated that during the first hour of mixing of the cements, they should be protected from water. Chuang et al. (12) demonstrated that surface coating was useful in decreasing marginal microleakage of RMGI cements. However, most manufacturers' instructions suggest that it is not necessary to use surface coating (12). There are many factors that can affect the marginal integrity of restorations, including the quality of isolation, the margin location, restorative material, insertion technique and polishing and finishing methods. Aside from the factors mentioned above, finishing and polishing methods are important to achieve an acceptable marginal integrity and also it is the only factor under the control of clinicians (13). The finishing technique determines the anatomical contour of the restorations; whereas, the polishing technique leads to smoothness of restorations (14).

It is hard to select an appropriate product for finishing and polishing considering the wide range of available products and instruments in the market (13). The commonly used tools for this purpose include the carbide burs (8-,11-, 15-, and 30-fluted), 25-50 µ diamond and abrasive-impregnated rubber cups and points, abrasive discs, abrasive strips, and polishing pastes (15). The polishing time is another important factor in cervical marginal integrity of restorations. Evidence shows that delayed polishing can decrease gap formation at the cervical margins of a RMGI or conventional glass ionomer restoration (15). However, Magni et al. (16) showed that gap formation in use of Fuji IX did not increase with immediate polishing. The purpose of this study was to compare the microleakage of class V RMGI restorations with different finishing and polishing times, methods of finishing and polishing and use/no use of surface coating. The null hypothesis of this study was that no significant difference exists in microleakage of class V RMGI restorations with different finishing and polishing times, methods of finishing and polishing and use/no use of surface coating.

Materials and Methods

In this in vitro study, 40 freshly extracted human premolars, which had no caries, cracks or defects, were collected and stored in 0.2% thymol solution for 2 weeks before the study. The study was approved by the ethics committee of our university (mubabol. rec.1395.255). Two standard class V cavities (mesiodistal width of 3 mm, occluso-gingival length of 2 mm, and a depth of 2 mm) were prepared on the buccal and lingual surfaces of each tooth with new straight fissure burs (#835/010, TeesKavan, Iran) for every five preparations. Occlusal margins of the cavities were in the enamel, and the gingival margins were in dentin approximately 1 mm below the cementoenamel junction. The dimensions of the cavities were verified with a periodontal probe. All the cavities were restored with encapsulated RMGI (Fuji II LC capsule; GC, Japan). The material was used following the manufacturer's instructions. The capsule was tapped on a hard surface to loosen the powder before its activation. Next, the capsule was placed in a metal GC Capsule Applier. The lever was clicked once and then it was removed and placed in an

amalgamator (Deggusa, Germany) and mixed for 10 seconds at high speed (± 4,000 rpm). The resin cement was injected directly into the cavity with GC Capsule Applier and light-cured for 20 seconds using a LED light curing unit (Valo, Ultradent, USA) with a light intensity of 1000 mw/cm^2. Table 1 shows the materials used in this study and Table 2 indicates the finishing and polishing instruments used in different groups. After polymerization, the prepared teeth were randomly assigned to eight experimental groups (n=10) according to the finishing and polishing time, technique and surface protection (Table 3). Groups 1-4 were finished and polished once while groups 5-8 were kept in artificial saliva (Hypozalix, Biocodex, France) at 37°C for 24 hours and then the specimens were finished and polished. According to the methods of finishing and polishing, half of the samples in all groups were finished and polished with aluminum oxide discs (Sof-Lex; 3M ESPE, St. Paul, MN, USA), and the remaining specimens were finished with long flame-shaped diamond burs (TeesKavan, Tehran, Iran) and polished with rubber points (Jiffy polishing point, Ultradent, USA) from coarse to fine. In groups 1, 3, 5 and 7, one layer of surface coating (G-Coat Plus, GC, Japan) was applied on the teeth instantly and light-cured for 20 seconds. G-Coat Plus is a mixture of urethane methacrylate, methyl methacrylate, camphorquinone, silicon dioxide, and phosphoric ester monomer and was used in the present study to coat the restorations. After the finishing procedure, all specimens were stored in a moist place at 37°C for 24 hours. Then, they were thermocycled for 1000 cycles at 5-55°C±2°C with a dwell time of 10 seconds. The apex of the teeth was sealed with sticky wax. Surfaces of the teeth were coated with nail varnish except for the restoration and 1 mm margin around it. The teeth were immersed in 0.5% basic Fuchsine solution for 24 hours and then they were mounted in epoxy resin and divided into mesial and distal halves using a cutting saw (Nemopars, Iran). The sections were blindly examined for marginal microleakage using a stereomicroscope (SMZ800; Nikon, Tokyo, Japan) at x40 magnification. The following criteria were used to score microleakage:

0 = No marginal leakage

1 = Penetration up to one-third of the full length of the cervical wall, or occlusal wall

2 = Penetration up to two-thirds of the cervical wall, or occlusal wall

3 = Penetration to more than two-thirds of the cervical wall, or occlusal wall up to the axial wall or towards the pulp

4 = Penetration into the axial walls.

Statistical analysis was performed with SPSS software version 23. The Mann-Whitney U test and general linear models were used to analyze the obtained data with $P<0.05$ level of significance.

Table 1. Composition and manufacturers of the materials used in this study

Material	Manufacturer	Composition
Fuji II LC Improved	GC Corporation, Tokyo, Japan	Powder: fluoroaluminosilicate glass Liquid: polyacrylic acid, HEMA
G-Coat Plus	GC Corporation, Tokyo, Japan	Urethane methacrylate, methyl methacrylate, Camphorquinone, silicon dioxide, phosphoric ester monomer

Table 2. Finishing and polishing instruments used in this study

Instruments	Manufacturer	Specifications of particle size
Sof-Lex Discs	3M ESPE, USA	Coarse (100 µm/150-grit) Medium (40 µm/360-grit) Fine (24 µm/600-grit) Extra fine (8 µm/200-grit)
Teeskavan Fine Diamond Finishing Burs	Teeskavan, Iran	Fine (30 µm)
Jiffy Polishing Points	Ultradent, USA	Coarse Medium Fine

Table 3. Classification of study groups according to the finishing and polishing time, technique and use of surface coating

Group number	surface coating	Finishing and polishing technique	Finishing and polishing time
1	Yes	Sof-Lex disc	Immediate
2	No		
3	Yes	Fine diamond bur	
4	No		
5	Yes	Sof-Lex disc	Delayed (after 24 h)
6	No		
7	Yes	Fine diamond bur	
8	No		

Results

The distribution of the frequency of microleakage scores in different groups is presented in Table 4. The comparison of microleakage in different groups is shown in Graph 1.

In terms of polishing time, there were no statistically significant differences between the groups with delayed or immediate finishing and polishing time ($P>0.05$). Regarding the polishing and finishing method, there were significant differences between the groups, and the microleakage score was lower in groups that were polished with discs ($P<0.001$).

Concerning surface coating, the groups coated with G-Coat Plus showed significantly lower microleakage than the ones without coating ($P<0.001$). There were no significant differences between the microleakage scores of gingival margins and the occlusal margins in any of the groups ($P>0.05$).

The results of general linear models with multinomial cumulative logit link function for comparison of microleakage in different groups are presented in Table 5.

Table 4. Distribution of the frequency of microleakage in different groups

		Sof-Lex discs										Fine diamond bur									
	Coating	Immediate					Delayed					Immediate					Delayed				
Frequency		0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
Gingival wall	Yes	7	1	0	1	1	4	4	1	1	0	1	5	3	0	1	1	1	4	4	0
	No	1	5	1	1	2	1	2	1	6	0	0	0	0	3	7	0	0	1	2	7
Occlusal wall	Yes	3	4	3	0	0	2	6	2	0	0	0	3	7	0	0	0	5	2	2	1
	No	0	4	4	2	0	2	2	3	2	1	0	1	1	5	3	0	1	1	3	5

Graph 1. Comparison of microleakage in different groups

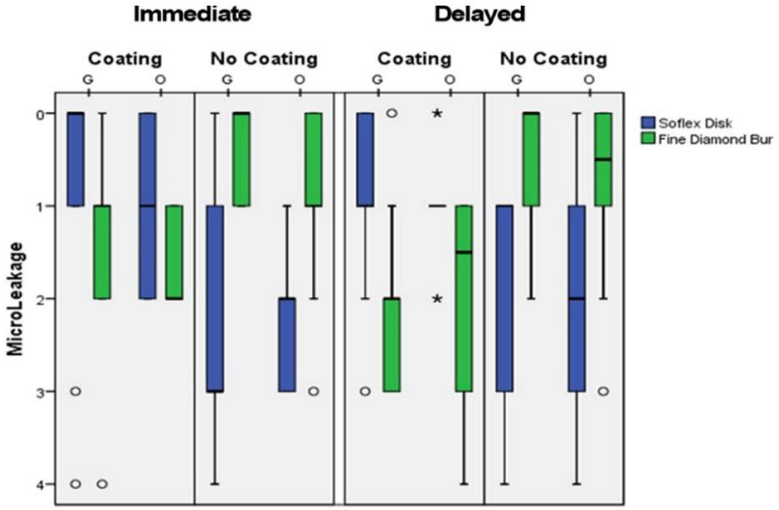

Table 5. Results of general linear models with multinomial cumulative logit link function for comparing microleakage in different groups

Parameters		B	Std. error	P-value
Time	Immediate	-0.063	0.61	0.917
	Delayed	Reference		
Method	Sof-Lex disc	-2.39	0.65	<0.001
	Fine diamond bur	Reference		
Surface coating	Yes	2.32	0.65	<0.001
	No	Reference		
Occlusogingival wall	Gingival wall	1.67	0.65	0.010
	Occlusal wall	Reference		
Time*method		-0.017	0.60	0.978
Time*surface coating		-0.187	0.60	0.754
Time*occlusogingival wall		-0.700	0.60	0.244
Method*surface coating		1.023	0.64	0.111
Method* occlusogingival wall		-1.006	0.60	0.094
Surface coating* occlusogingival wall		-1.297	0.60	0.031

Discussion

A key factor in success of restorations in restorative dentistry is to achieve maximum marginal integrity. Studies have reported that marginal microleakage is the main reason for failure of restorations (17-20). Therefore, in our study, we investigated the effect of some potential factors, such as the time and methods of finishing and polishing, and also the use of a light-curable coating on sealability of RMGI restorative material in class V restorations.

With regard to the use of surface coating, none of the groups demonstrated complete marginal sealing at either of the occlusal or cervical margins similar to the findings of Chuang et al (12). Lower microleakage was observed when G-Coat Plus was applied compared with the uncoated samples. The differences were significant in all groups except for the occlusal margin of samples finished with Sof-Lex discs after 24 hours, and this finding was in accordance with the results of Magni et al. (16) This might be due to achieving a good occlusal seal without the need for an additional coating in glass ionomers (16). It seems that the application of surface coating can preserve the water balance of the RMGI, fill small defects at the margins of the restorations and decrease the amount of microleakage (21).

There are numerous finishing and polishing products in the market making it difficult to choose the proper instrument with the least destructive effect on restoration margins (13). Our results indicated that the samples that were accurately finished and polished with Sof-Lex discs had significantly lower microleakage compared with those finished and polished with diamond bur and rubber points when surface coating was not applied. In groups coated with G-Coat Plus which were finished immediately, the difference between the two methods of finishing and polishing was not significant. Yap et al. (22) reported that utilizing diamond burs with ultra-high speed hand-pieces can destroy the bond between RMGI and tooth structure and also destruct the polygel matrix of the material that might contribute to higher marginal leakage compared with Sof-Lex discs.

It seems that in our study, application of G-Coat Plus hindered the negative effect of diamond burs on the marginal gap. Finishing and polishing with Sof-Lex discs after 24 hours also resulted in significantly lower microleakage compared with diamond bur except for the occlusal margin in samples with surface coating.

In the present study, in terms of finishing and polishing time, occlusal and cervical microleakage were not affected in any of the groups. These results were in accordance with those of an earlier study by Mirzaei et al, (17) but did not confirm the observations of Irie et al, (23) who mentioned that delayed polishing was better in preventing interfacial gap formation between the glass ionomer material and the class I cavity. These differences can be related to different types of glass ionomers, cavity type and polishing instruments. Application of G Coat Plus in our study could have decreased interfacial gap formation in Fuji II LC Improved when polished immediately.

Our results showed that there were no statistically significant differences between enamel and dentinal walls with regard to marginal microleakage scores. Several previous studies demonstrated lower microleakage in enamel margins restored with adhesive restorative materials (15,24-26). Yap et al. (22) reported that when conventional glass ionomer cement was used, the sealability of enamel margins was significantly higher with all the polishing techniques. In the current study, a resin-modified glass ionomer restorative material was used. This relative enhancement in dentin sealability of RMGI has been reported in previous studies (27,28) and is attributed to lower water uptake and immediate adhesion to tooth structure compared with conventional glass ionomers that adhere over time.

Conclusion

Within the limitations of the present study, it can be concluded that coating of restorations in groups finished and polished with Sof-Lex discs can decrease the amount of microleakage. Also, it is more effective at the gingival margin.

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