

The Study of Effectiveness of Various Surface Sealants on the Sealing Ability in Class V Glass-Ionomer Restorations

Sınıf V Cam İyonomer Restorasyonlarda Çeşitli Yüzey Örtücülerin Sızdırmazlık Kabiliyeti Üzerindeki Etkinliğinin İncelenmesi

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ABSTRACT

Objective: The study aims to investigate whether the surface sealants applied on the materials in Class V cavities restored using different glass ionomer materials have an effect on the microleakage of the materials.

Methods: 120 extracted non-carious human premolar teeth were used in the study. Teeth were randomly divided into three groups of 40 teeth for each and restored with conventional glass-ionomer cement (GIC), resin-modified glass-ionomer cement (RMGIC) and polyacid-modified resin composites (PMRC). Protect-it, LC Varnish and Finishing Gloss surface sealants were applied to these filling materials separately, apart from the control group. The microleakage of occlusal and cervical margin was evaluated separately. The data were statistically analyzed with the Kruskal-Wallis One-Way ANOVA test, and Mann-Whitney U test.

Results: According to the results obtained, in the occlusal and cervical margins, there was a statistically significant difference between conventional GIC and RMGIC ($P<.05$), but there was no statistically significant difference between PMRC and the others. For the conventional GIC, Protect-it and LC Varnish were the most effective surface coating among the tested materials, while the best surface protection was obtained with LC Varnish and Finishing Gloss in the PMRC. The lowest level of leakage at cervical margin was achieved with Protect-it and LC Varnish in conventional GIC and with LC Varnish in the PMRC.

Conclusion: In this study, it has been shown that the use of restorative materials with surface protection provides a reduction in the amount of margin leakage and may therefore contribute to the success of the restoration.

Keywords: Conventional glass-ionomer cement, microleakage, polyacid-modified resin composites, resin-modified glass-ionomer cement, surface sealant

ÖZ

Amaç: Çalışmanın amacı, farklı cam iyonomer malzemeler kullanılarak restore edilen Sınıf V kavitelelerdeki malzemelere uygulanan yüzey koruyucuların, malzemelerin mikrosızıntısına etkisinin olup olmadığını araştırmaktır.

Yöntem: Çalışmada 120 adet çekilmiş çürüksüz insan premolar dişi kullanıldı. Dişler rastgele her biri 40 dişten oluşan üç gruba ayrıldı ve geleneksel cam iyonomer siman (GCIS), rezin modifiye cam iyonomer siman (RMCIS) ve poliasit modifiye kompozit rezin (PMKR) ile restore edildi. Bu dolgu malzemelerine kontrol grubu dışında ayrı ayrı Protect-it, LC Varnish ve Finishing Gloss yüzey örtücüleri uygulandı. Oklüzal ve servikal kenardaki mikrosızıntıyı ayrı ayrı değerlendirildi. Veriler Kruskal-Wallis, One-Way ANOVA testi ve Mann-Whitney U testi kullanılarak analiz edildi.

Bulgular: Elde edilen sonuçlara göre oklüzal ve servikal kenarlarda GCIS ile RMCIS arasında istatistiksel olarak anlamlı fark bulunurken ($P<.05$), PMKR ile diğerleri arasında istatistiksel olarak anlamlı fark bulunamadı ($P>.05$). GCIS için, test edilen malzemeler arasında en etkili yüzey koruması Protect-it ve LC Varnish ile olurken, PMKR'de LC Varnish ve Finishing Gloss ile elde edilmiştir. Servikal kenarda ise en düşük sızıntı, GCIS'da Protect-it ve LC Varnish ile, PMKR'de ise LC Varnish ile elde edildi.

Sonuç: Bu çalışmada yüzey koruyucu restoratif materyallerin kullanımının marj sızıntısı miktarında azalma sağladığını ve dolayısıyla restorasyonun başarısına katkıda bulunabileceği gösterilmiştir.

Anahtar Kelimeler: Geleneksel cam iyonomer siman, mikrosızıntı, poliasit modifiye kompozit rezin, rezin modifiye cam iyonomer siman, yüzey örtücü



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INTRODUCTION

Microleakage is used to express the passage of saliva, intraoral liquids, chemical agents, ions and microorganisms through the small or microscopic spaces between the filling materials and cavity walls.¹ This may lead to staining in the filling, deterioration of the outer edges and adjacent caries, as well as postoperative sensitivity and infection in the pulp.² Differences between the filling materials and physical properties of teeth – especially polymerization shrinkage, expansion coefficient and elastic modulus – may cause leakage.² Therefore, research in recent years has concentrated on the physical qualities of restorative materials.

Glass-ionomer cements (GIC) are the filling materials that chemically bonded to tooth tissues and release fluoride in the first few weeks.³ That it takes a short time to place them into cavity is one of the advantages of these filling materials. The thermal expansion coefficient of traditional GICs is close to that of dental tissues. This indicates that GICs have good marginal adaptation ability.⁴ In many clinical studies, it has been shown that the GIC can be used as a successful restoration material in smooth surface caries and in the interproximal cavities of the anterior teeth, ie cavities in the area with less stress.⁵ Besides these advantages, conventional GICs are significantly sensitive to moisture in the early stages of placement, as these materials have a hardening time of approximately seven minutes after starting to mix. For this reason, moisture isolation during hardening is very important.^{6,7} Gemalmaz et al.⁸ reported that the amount of soluble matrix is high during the hardening of GIC, especially in the first 6 minutes, and if any moisture contamination occurs during this time, the solubility of the matrix will increase and the mechanical properties of the material will weaken.

To overcome the problems of the moisture sensitivity and low early mechanical strength problems associated with traditional GICs, hybrid versions of the GIC were subsequently developed. It has been observed that these materials so-called resin-modified glass ionomer cements (RMGIC) have a longer working time, faster hardening, improved appearance and translucency, and higher early strength compared to traditional GICs.⁹ The coefficient of thermal expansion of RMGIC is significantly higher than that of conventional GIC and also less than that of composite resin.⁴ It is less sensitive to water than conventional GIC.¹⁰ Polyacid-modified resin composite (PMRC) is a filling material produced with the combination of glass-ionomer with the composite resin, developed to overcome poor margin adaptation and its negative effects.² It is more aesthetic and translucent than the conventional GICs as well as more adaptive to dental tissues in terms of color. However, it requires a dry environment until the polymerization process is completed.¹¹

Since ensuring the marginal integrity and sealing of the restoration will significantly increase the longevity of the restoration, many methods have been used by researchers to reduce the marginal space at the tooth-restoration interface. One of the suggested techniques is to apply surface sealants on the restorations, thus closing the micro-voids and sealing the restoration and its edges. These materials, in addition to providing impermeability, increase the wear resistance of the material, reduce discoloration and ensure the cleanability of the restoration surface. It has been reported that coating materials strongly bind to dental tissues and restorative materials.¹² The protective effects of surface sealants against bleaching agents have also been reported in the literature.^{6,13-15} As a result, surface sealants are considered beneficial in increasing marginal integrity.

This study was conducted to compare the margin microleakage of conventional glass ionomer cement, resin modified glass ionomer cement and polyacid modified resin composites in Class V restorations

and to investigate whether the different surface sealants, used together with them, would influence or not the leakage.

The null hypothesis was that there was no significant effect on the microleakage of the materials after the surface sealants were used on different restorative materials.

METHODS

Sample Size Determination

The sample size was determined by G*Power 3.1.9.4 software (Heinrich-Heine Dusseldorf University, Dusseldorf, Germany) using the following parameters: 84% power, 0.39 effect size, and α error at 0.05. It was determined that the appropriate total sample size should be a minimum of 117 samples.

Specimen Selection

This study was carried out with the ethical approval of Pamukkale University Faculty of Dentistry Ethics Committee (Date: 20.09.2023, No: E.421344). A total of 120 human premolar teeth extracted for prosthetic and/or periodontal reasons were used in the study. Teeth with any fractures, cracks, caries lesions, wear or erosion, and restorations were not included in the study. Soft tissue remaining on the teeth was eliminated using a hand scaler. Disinfection of the teeth was done with 0.1% chloramine for 48 hours followed by storing in distilled water at 4°C until used.

Cavity Design

On the buccal surfaces of these teeth, Class V cavities were prepared (the width of 3 mm, height of 2 mm and depth of 2 mm and with the occlusal margin in enamel and cervical margin in cementum) using a diamond fissure bur (KG Sorensen, Zenith Dental ApS, Agerskov, Denmark) on a high-speed handpiece with an air-water cooling spray. The bur was changed after every five preparations. Cavity dimensions were standardized using a periodontal probe. All cavosurface angles were kept at 90 degrees without bevel designs. All of cavity preparations were made, all by the same operator.

Study Groups and Restorative Procedure

These teeth were divided into three groups, each with 40 teeth randomly selected and the teeth in each group were restored following the manufacturers instructions using the filling materials of conventional glass-ionomer cement (Ionofil U, Voco, Cuxhaven, Germany), resin-modified glass-ionomer cement (Vitremmer, 3M Dental Products, St Paul, MN, USA) and polyacid-modified resin composite (Dyract AP-DeTrey, Dentsply, Konstanz, Germany) (Table 1). The excesses in the restorations were removed and their filling surfaces were polished with aluminum oxide discs (3M Dental Products, St Paul, MN, USA). The specimens prepared for Vitremmer and Dyract AP were light-cured for 40 seconds using a visible blue LED light device (Elipar Freelight II, 3M Oral Care, St. Paul, MN, USA) at a wavelength of 430-480 nm (light intensity:1200 mW/cm²). Ionofil U specimens were left for 5 minutes for hardening.

Then these groups were divided into 4 subgroups with 10 for each; and each subgroup was applied the following surface sealants, such as Finishing Gloss (3M Dental Products, St Paul, MN, USA), Protect-it (Jeneric/Pentron, Inc, Wallingford, CT, USA) and LC Varnish (Spofa Dental, A Kerr Company, Markova, Jicin, CZ) (Table 1). In addition, surface sealants were not applied to a subgroup of each filling material and they were considered as the control group.

Microleakage Assessment

The specimens were stored for a week in distilled water at 37 °C and then placed in a thermocycling machine (between 5 - 55°C, 30 seconds dwell time, 3 sec transfer time, 500 cycles). To prevent some possible

penetration from different sites, the apex of each tooth was sealed with sticky wax, and all the surfaces, except 1 mm beyond the margin of the restoration site, were coated with nail varnish (Colorama, CEIL-Com Exp Ltda, Sao Paulo, SP, Brazil). Then they were kept in 2 % basic fuchsin dye solution for 24 hours at room temperature.

Table 1. Materials used in this study.

Material	Manufacturer	Composition ^a	Type
Ionofil U	Voco, Cuxhaven, Germany	FAS, PAA, water	Restorative material
Vitremer	3M Dental Products, St Paul, MN, USA	FAS, PMAA, HEMA	Restorative material
Dyract AP	DeTrey, Dentsply, Konstanz, Germany	UDMA, TCB, TEGDMA, Trimethacrylate resin	Restorative material
Protect-it	Jeneric/Pentron, Inc, Wallingford, CT, USA	BisGMA, UDMA, TEGDMA, THFMA	Surface sealant
Finishing Gloss	3M Dental Products, St Paul, MN, USA	BisGMA, TEGDMA	Surface sealant
LC Varnish	Spofa Dental, A Kerr Comp, Markova, Jicin, CZ	BisGMA, UDMA	Surface sealant

FAS: aluminium fluorosilicate glass, PAA: polyacrylic acid, PMAA: polymethacrylic acid, HEMA: hydroxyethylmethacrylate, UDMA: urethane dimethacrylate, TCB: carboxylic acid modified dimethacrylates, TEGDMA: Triethyleneglycoldimethacrylate, BisGMA: Bis-phenol A diglycidylmethacrylate.

Table 2. Comparison of microleakage in the control groups of conventional GIC, PMRC and RMGIC control groups at occlusal and cervical margins

	n	Occlusal Margins			Cervical Margins		
		Mean Rank	χ^2	P*	Mean Rank	χ^2	P*
GIC	10	21.9 ^a	11.65	.003	20.9 ^a	7.3	.026
PMRC	10	15.1 ^{ab}			14.1 ^{ab}		
RMGIC	10	9.5 ^b			11.5 ^b		

GIC: Conventional Glass-Ionomer Cement, PMRC: Polyacid-Modified Resin Composite, RMGIC: Resin-Modified Glass-Ionomer Cement *Results of Kruskal-Wallis One-Way ANOVA test

^{a,b,c}Results of Mann-Whitney U test (Means with the same letter are not significantly different)

leakages were evaluated under x40 magnified stereomicroscope (Nikon SE, Nikon, Tokyo, Japan) following with the criteria below^{16,17}:

0. No dye penetration.
1. Partial dye penetration (up to 1/3 of the occlusal or gingival wall length) along the occlusal or gingival wall
2. Dye penetration along the occlusal or gingival wall (superior to 1/3 of the occlusal or gingival wall length), but not including the axial wall;
3. Dye penetration to and along the axial wall.

Statistical Analysis

All data were statistically analysed by means of Kruskal-Wallis One-Way ANOVA test at 5% significance level ($P < .05$) for multiple group comparison followed by Mann-Whitney U-test for pairwise comparison and were tabulated.

RESULTS

Photographs of each score are given in Figure 1. In the control groups of conventional GIC, PMRC and RMGIC, the microleakage values (mean rank values) measured on the occlusal and cervical margins and their statistical comparison were given in Table 2. As seen in Table 2, in the occlusal and cervical margins, there was a statistically significant difference between conventional GIC and RMGIC ($\chi^2=11.65$, $P < .01$; $\chi^2=7.3$, $P < .05$, respectively), but there was no statistically significant difference between PMRC and the others. In addition, the lowest microleakage amount was observed in the resin-modified glass-ionomer cements in the measurements made on either margin.

Multiple comparisons of surface sealants for conventional GIC, PMRC and RMGIC were given in Table 3 for occlusal and cervical margins. In the measurements made on the margins of both occlusal and cervical, there were found statistically significant differences between control groups and the surface sealants in conventional GIC ($\chi^2=27.392$, $P < .0001$; $\chi^2=26.114$, $P < .0001$, respectively) and PMRC ($\chi^2=27.585$, $P < .0001$; $\chi^2=23.495$, $P < .0001$, respectively). In the evaluations made on either

Table 3. The statistical comparisons and mean rank values of different surface sealants used with classical GIC, PMRC and RMGIC at occlusal and cervical margins.

		Conventional Glass-Ionomer Cement			Polyacid-Modified Resin Composite			Resin-Modified Glass-Ionomer Cement		
		Mean Rank	χ^2	p*	Mean Rank	χ^2	p*	Mean Rank	χ^2	p*
Occlusal Margins	Protect-it	10	12.3 ^a	27.392	18.9 ^a	27.585	0.0001	19.3 ^a	18.721	0.0001
	LC Varnish	10	13.75 ^a		14.1 ^a			12.5 ^a		
	Finishing Gloss	10	20.6 ^b		14.1 ^a			19.3 ^a		
	Control	10	35.35 ^c		34.9 ^c			30.9 ^b		
Cervical Margins	Protect-it	10	12.5 ^a	26.114	21.65 ^a	23.495	0.0001	18.2 ^a	6.99	0.072
	LC Varnish	10	12.5 ^a		11.15 ^b			19.7 ^a		
	Finishing Gloss	10	22.7 ^b		15.8 ^{ab}			16.2 ^a		
	Control	10	34.3 ^c		33.4 ^c			27.9 ^a		

*Results of Kruskal-Wallis One-Way ANOVA test.

^{a,b,c}Results of Mann-Whitney U test (Means with the same letter are not significantly different)

Following removal from the solution, the teeth were rinsed under running water for 1 h and mounted in an autopolymerizing clear acrylic resin material (Orhocril EQ, Dentaurum, Ispringen, Germany) to facilitate handling during sectioning. Then, specimens were sectioned bucco-lingually through the centre of the restoration with a diamond disk (Buehler, Lake Bluff, IL, USA). A scale of tenths of a millimeter was used to measure dye penetration amounts and the scores of their

margin, it was seen that the most effective surface sealant, namely the lowest microleakage amount, was observed with Protect-it and LC Varnish in the conventional GICs and with LC Varnish and Finishing Gloss in the PMRCs. In the RMGICs, however, there was not found a statistically significant difference between the surface sealants and the control group in the measurements made on the cervical margins ($\chi^2=6.99$, $P > .05$). On the other hand, it was determined that there was a statistically significant difference between the surface sealants and the

control group in the measurements made on the occlusal margins ($\chi^2=18.721$, $P<.0001$), but the differences between the surface sealants were not statistically significant ($P>.05$).

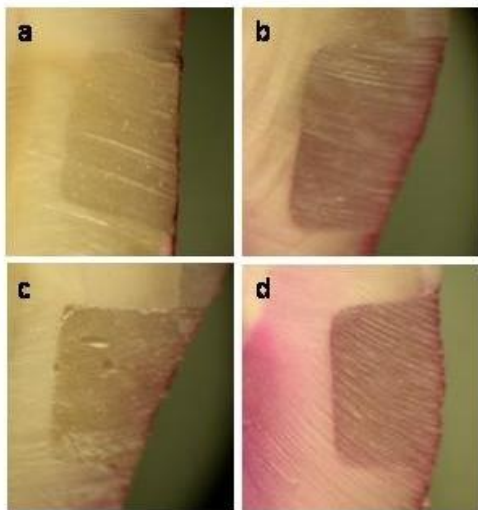


Figure 1. Leakage levels detected in sectioned teeth
a. 0. No dye penetration; b. 1. Partial dye penetration (up to 1/3 of the occlusal or gingival wall length) along the occlusal or gingival wall; c. 2. Dye penetration along the occlusal or gingival wall (superior to 1/3 of the occlusal or gingival wall length), but not including the axial wall; d. 3. Dye penetration to and along the axial wall.

DISCUSSION

Cervical restorations have been carefully analyzed by researchers as it contains the dentin and cement in gingival and the enamel in occlusal.^{16,18} Due to the different physical and chemical properties of the filling materials used in such restorations, they bind to enamel and cement to different degrees. As a result, this causes the amount of leakage to differ between enamel and cement. The filling materials most commonly used in such restorations are the ones that contain glass-ionomer. GICs are sensitive to hydration and dehydration during their initial hardening. It has been reported that the changes in the mechanic qualities of the filling as a result of its contact with water at the initial stage of hardening leads to a weak clinical performance.^{19,20} On the other hand, the reduction in the degree of hydration during the formation of matrix has been reported to lead to a lower compressive resistance. In this connection, the most important reason why the leakage in GICs has been shown as the fact that cement is hardened with the acid-base reaction and this hardening is completed in as long a period as 24 hours.^{19,20}

The first significant modification of glass ionomers came through the addition of small quantities of light-polymerizable resin groups. These materials called resin-modified glass-ionomer cement were developed to overcome the problems of hydration and dehydration associated with conventional GICs. But the same problems were also observed in these materials.^{21,22} It has been found out that RMGICs yield to less leakage in most studies than conventional glass-ionomer cements.^{23,24} The less leakage of RMGIC compared to conventional GIC may be due to the different hardening reactions of these two materials. In case of moisture contact at the beginning of hardening in conventional GIC, matrix forming ions (Ca and Al) can be washed away and this may cause matrix formation with poor mechanical properties and consequently microleakage. Another reason is that the hardening process of RMGIC

takes place in two stages, the acid-base reaction and the photopolymerization reaction. In this, water is partially replaced by hydroxyl ethyl methacrylate. The structure of RMGIC consists of a matrix of metal polyacrylate salts and a polymer matrix. Therefore, RMGIC may have shown lower microleakage than conventional GIC.⁶ In studies comparing the microleakage of glass-ionomer, composit resin and compomer, Erdilek et al.,²⁵ and Mali et al.,²⁶ found that compomer demonstrated the best results with minimum leakage. In their study, Brackett et al.,²⁷ restored Class V cavities using compomer and RMGIC and evaluated the leakage at the edges of the restoration. They reported that RMGICs showed less or similar microleakage than the polyacid-modified composite resin tested. As with other light-curing restoratives, polymerization shrinkage is a problem for PMRCs. These materials set via a free radical polymerization reaction, and do not have the ability to bond to hard tooth tissues. For this reason, they are used with resin-bonding agents for their adhesion to tooth. In this study, although PMRC leakage rate was higher than RMGIC, the difference was not significant. This difference could be explained by the fact that PMRC contained more resin and consequently showed more polymerization shrinkage.

As a result, in the present study, too, the comparison between the control groups has shown the least amount of leakage with RMGICs and the highest amount of leakage with the conventional GICs. Therefore, the null hypothesis was rejected. However, the amount of leakage in each of three restorative materials was rather high parallel to the previous studies.^{1,16} Therefore, recent research in this field has focused on eliminating the problem in point.^{28,29} From this point of view, it has been considered that surface sealants should be applied over these filling materials because GICs have their structure spoilt under the influence of humidity.²⁸ In the announcement by ADA in 1990, it was remarked that it was important to apply surface sealants or light-polymerized bonding agents for conventional GIC restorations.²⁹ Some types of coating agents can be cured with light curing units and can provide optimal marginal coverage and preservation of the tooth and restoration margin, as well as prevent discoloration of restorative materials, helping to create a smooth, glossy and durable surface. Similarly, a previous study has shown that unfilled and nano-filled surface sealants are the most effective method in reducing the degree of marginal microleakage at the dentin margins.³⁰ Hotta et al.,²⁸ found that the use of a waterproof coating agent provided sufficient early protection to prevent water gain or loss from the hardening glass ionomer. Likewise, Erhardt et al.,¹ in their study, suggested that the surface protection should be used to reduce margin microleakage of RMGIC and PMRC restorations. In the present study as well, in agreement with other studies,^{7,12,31,32} it was found that the surface coating significantly reduced microleakage in Class V resin restorations.

In the present study, there was found a significant difference between the control groups and the surface sealants used in the conventional GICs and PMRCs according to the evaluations made on the edges of cavities the cervical and occlusal. In the RMGICs, however, this difference was only statistically significant in the measurements made on the occlusal margins. It has also been reported in the researches that the use of restorative materials along with surface sealants affects the success of treatment positively.^{1,27,33-35} However the effectiveness of the preferred surface sealants may also differ. Therefore, the choice of the most suitable restorative material-surface sealant combination can be regarded as another factor affecting success. In a study by Karođlanođlu et al.,³³ they determined that dye-absorption qualities of different surface sealants used with compomers are different and the dye-absorption is the least with Finishing Gloss and the highest with LC

Varnish. Cefaly et al.,³⁴ could not find a statistically significant difference between the efficiency of different surface sealants used with RMGICs. In the measurements made on both edges in the present study, the most effective surface sealants were found Protect-it and LC Varnish for conventional GICs, LC Varnish, Finishing Gloss and Protect-it for PMRCs, respectively. However, in RMGICs, although all surface sealants were effective in reducing leakage at occlusal margins, the differences between them were not statistically significant. These results appear to be in agreement with those of Karaođlanođlu et al.³³ and of Cefaly et al.,³⁴. Ramos et al.,³⁵ reported that Fortify and Protect-it showed better results in the cervical region than the control group, Tyagi et al.,⁷ and Yilmaz et al.,³⁶ reported that LC Varnish was effective as a surface protectant.

This study has several limitations. First of all, although coating agents reduced microleakage in the present study, oxygen in the oral environment may inhibit the polymerization of the surface sealant and clinical findings may be affected. On the other hand, coating materials can be degraded by saliva, food, brushing, opposing surfaces or other substances in the oral environment. Therefore, further in vivo long-term studies are recommended to obtain clearer findings on the efficacy of coating materials.

CONCLUSION

The amount of leakage of restorative materials was RMGIC, PMRC, and GIC, from least to greatest, respectively. The use of these fillings in combination with various surface sealants such as Protect-it, LC Varnish, Finishing Gloss has significantly reduced leakage, although there are differences in their effectiveness. Since some restorative material-surface sealant combinations such as GIC-LC Varnish/Protect-it, PMRC-LC Varnish, RMGIC-LC Varnish give the most satisfactory results, these combinations may be preferred to ensure an effective seal in clinical use.

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