Original Article

Microleakage of Glass Ionomer based Restorative Materials in Primary Teeth: An *In vitro* Study

B Ayna, S Çelenk, O Atas[1], EC Tümen, E Uysal[2], IR Toptanci

Department of Pedodontics, Faculty of Dentistry, Dicle University, [2]Department of Technique, Vocational High School, Dicle University, Diyarbakir, [1]Department of Pedodontics, Faculty of Dentistry, Firat University, Elazig, Turkey

ABSTRACT

Aim: Using AutoCAD, we examined the microleakage of dye at the edges of primary-teeth restorations using three glass ionomer-based restorative materials. **Materials and Methods:** A total of 30 extracted noncarious primary molars were used. Class V cavities were adjusted on the buccal surfaces. The teeth were randomly divided into three groups of 10 teeth each as follows: Group A (Ketac Molar), Group B (Photac Fil), and Group C (Dyract XP). All specimens were stored for 24 h at 37°C in distilled water. The teeth were thermocycled 1000 times between 5°C ± 2°C and 55°C ± 2°C before immersion in 0.5% basic fuchsin for 24 h. Two mesiodistal cuts of each tooth were photographed under a stereomicroscope equipped with a digital camera. The dye-infiltrated surface area was measured. Statistical evaluations were performed by the Kolmogorov–Smirnov test, Levene test, one-way analysis of variance, and Tukey's honestly significant difference test. **Results:** The mean microleakage ratio differed significantly among the groups ($P < 0.05$). Group C exhibited a significantly smaller area ($P < 0.001$) than the other groups. Group A had a nonsignificantly higher mean microleakage value than Group B ($P > 0.05$). **Conclusions:** Polyacid-modified composite resin may be a useful restorative material in primary teeth in terms of minimizing microleakage.

Date of Acceptance:
04-Apr-2018

Keywords: *Glass ionomer-based restorative materials, microleakage, primary teeth*

Introduction

To eliminate tissue loss and meet esthetic requirements, diverse restorative materials have been produced. For primary and permanent teeth, the most important issue with restorative materials is microleakage, which cannot be prevented.[1-3] Many microleakage studies are still being made from the past to the present day.[1-5]

Microleakage involves the ingress of bacteria, ions, and fluids from the oral cavity between the wall of the cavity and the restoration and results in failure of the restoration.[6,7] Therefore, adhesion of restorative materials to dental tissue is important. The ideal restorative material should have similar physical characteristics to dental tissues, should adhere well to dentin and enamel, and should not undergo structural changes in the oral environment.[8,9] Although no restorative material with all of these features is available, the production of restoration materials that can adhere chemically to dentin and enamel and release fluorine is at an important stage. The glass ionomer cements (GICs) developed toward the end of the 20th century by McLean and Wilson and Kent are now in use.[10]

However, the early conventional GICs have limitations in their use in areas exposed to intense chewing forces due to their low resistance to breaking and abrasion, as well as their sensitivity to dryness and moisture.

To reduce their susceptibility to humidity, increase their stiffness and resistance to abrasion, and enable their use in areas exposed to intense chewing forces, GICs

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_143_17

Address for correspondence: Dr. B Ayna, Department of Pedodontics, Faculty of Dentistry, Dicle University, Diyarbakir, Turkey. E-mail: buketayna@hotmail.com

How to cite this article: Ayna B, Çelenk S, Atas O, Tümen EC, Uysal E, Toptanci IR. Microleakage of glass ionomer based restorative materials in primary teeth: An *In vitro* study. Niger J Clin Pract 2018;21:1034-7.

were strengthened by changing the powder: liquid ratio, particle size, and distribution.[11,12] Moreover, high-viscosity GICs are now available.[13,14]

Resin-modified GIC (RMGIC) and polyacid-modified composite resin (PMCR) contain resins in different proportions and are commonly used in primary teeth.[15,16] However, there is no consensus regarding the potential for microleakage using these restorative materials.

Microleakage studies typically use subjective analysis ratings.[17] However, microleakage can be measured quantitatively by volume addition with AutoCAD, which outputs a mathematical total area.[18,19]

Therefore, we investigated microleakage at the edges of primary-teeth restorations using three different glass ionomer-based restorative materials.

Materials and Methods

This study was approved by the Local Ethics Committee of the Dicle University Faculty of Dentistry (dated March 6, 2013; number 2013-2). A total of 30 noncarious primary molars extracted for orthodontic purposes or because of overretention were used. Superficial debris was removed using a hand scaling apparatus. The teeth were stored in balanced salt solution at 22°C–24°C. Classical class V cavities (3 mm width, 2 mm height, and 2 mm depth) were adjusted using a high-speed handpiece with water cooling at the cement–enamel junction on the buccal mucosa. The teeth were randomly divided into three groups of 10 teeth each: Group A (Ketac Molar), Group B (Photac Fil), and Group C (Dyract XP) [Table 1].

Group A: Ketac Conditioner (3M ESPE AG, Seefeld, Germany) was applied to the cavities using a disposable brush for 30 s and rinsed three times with a moist cotton pellet. A stainless-steel band was adapted to the teeth. The Ketac Molar capsule was activated (Aplicap System, Activator; 3M ESPE AG) and mixed according to the manufacturer's instructions. GIC was inserted directly into the cavities through the capsule adapted to a metallic applicator (Aplicap System, Applier (73050); 3M ESPE AG).

Group B: The conditioning procedures and the stainless-steel band adaptation were performed as in Group A. The Photac Fil capsule was activated (Aplicap System, Activator; 3M ESPE AG) and mixed according to the manufacturer's instructions. RMGIC was inserted into the cavities directly through the capsule adapted to a metallic applicator (Aplicap System, Applier; 3M ESPE AG). Next, the restoration was condensed, contoured using a plastic filling instrument, and cured for 40 s. The cavities were restored and light cured for 40 s using a visible light curing device (HS LED 1500; Henry Schein Inc., Melville, NY, USA) according to the manufacturer's instructions.

Group C: The prepared cavities were engraved with 37.5% phosphoric acid (Ultra-Etch; Ultradent Products Inc., South Jordan, UT, USA) for 30 s (enamel) or 15 s (dentin), thoroughly soaked in water for 30 s, and lightly dried with compressed air, leaving the surface moist. Prime and Bond NT (Dentsply Sirona, Konstanz, Germany) was applied to the enamel and dentin. The solvent was detached with air, and the adhesive was light cured for 10 s. The PMCR restorative material was placed over the cured Prime and Bond NT and cured for 40 s.

Final finishing and polishing of the restorations were performed using Sof-Lex discs (3M ESPE AG) in a slow-speed handpiece on a micromotor. The samples were stored for 24 h at 37°C in distilled water. The teeth were thermocycled 1000 times between 5°C ± 2°C and 55°C ± 2°C, with a dwell time of 30 s and transfer time of 3 s.

The apices of all teeth were sealed with composite resin, and all external surfaces were isolated with two layers of nail varnish, except up to 1 mm from the restoration margin. The specimens were immersed in 0.5% basic fuchsin for 24 h. The samples were washed thoroughly with pumice slurry to remove residual dye. The specimens were embedded in autopolymerizing acrylic resin (Temdent; Schütz Dental, Rosbach vor der Höhe, Germany) and longitudinally sectioned in the occlusogingival direction at the center of each restoration using a precision cutting machine (IsoMet; Buehler Ltd., Lake Bluff, IL, USA). A total of 20 sections were obtained from 10 teeth. Two mesial distal cuts of each tooth were photographed for microleakage at ×40 magnification under a Leica S8 APO stereomicroscope (Leica Microsystems, Sijhih, Taiwan) equipped with a digital camera (Olympus DP25; Olympus Corp., Tokyo, Japan). The images were transferred to a personal computer and stored in TIFF format. The dye-infiltrated surface area was measured using AutoCAD 2014 software (Autodesk Inc., San Rafael, CA, USA). The data were tabulated and subjected to statistical analysis (Kolmogorov–Smirnov test, Levene test, one-way analysis of variance [ANOVA], and Tukey's honestly significant difference [HSD] test). $P < 0.05$ was considered statistically significant.

Results

Microleakage differed significantly among the three groups, as determined by a one-way ANOVA [$P < 0.05$; Table 2].

Group C showed a significantly smaller microleakage area than the other two groups ($P < 0.001$). Group A

Table 1: Descriptions of, and manufacturer information for, the materials evaluated

Group	Restorative material	Commercial name	Manufacturer
Group A	Conventional glass ionomer cement	Ketac Molar	3M ESPE AG, Germany
Group B	Resin-modified glass ionomer cement	Photac Fil	3M ESPE AG, Germany
Group C	Polyacid-modified composite resin	Dyract XP	Dentsply Sirona, Germany

Table 2: Microleakage values

Group	Number of samples	Mean microleakage area±SD
Group A (Ketac Molar)	20	6543.82±2744.79
Group B (Photac Fil)	20	5655.24±1344.40
Group C (Dyract XP)	20	2442.14±2702.31

SD=Standard deviation

Table 3: Microleakage ratios

	Group A (Ketac Molar) A	Group B (Photac Fil) B	Group C (Dyract XP) C
Microleakage ratio	6543.82	5655.24	2442.14

A–B=P>0.05; A–C=P<0.001; B–C=P<0.001. F=15.946

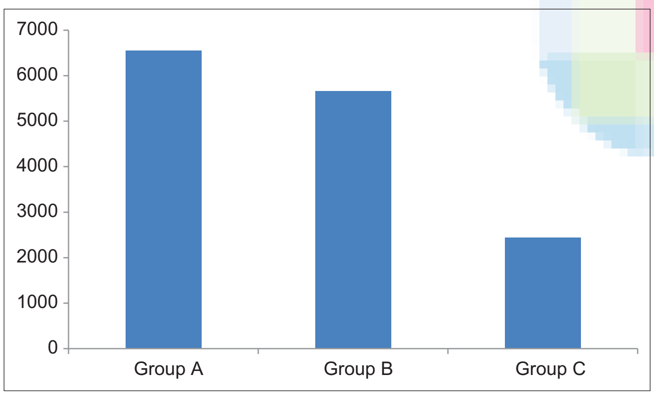

Figure 1: Mean microleakage values. Group A, Ketac Molar; Group B, Photac Fil; Group C, Dyract XP

had a nonsignificantly (P < 0.05) larger mean microleakage area than Group B (Tukey's HSD test); [Table 3 and Figure 1].

Discussion

Microleakage is an important determinant of the clinical life of a restorative material. *In vitro* microleakage detection tests are important for providing information about microleakage of restorative materials and the coverage of the material.[1,20] Therefore, the microleakage properties of materials were investigated *in vitro* by the dye penetration method in this study. The microleakage area of PMCR was significantly smaller than that of conventional GIC and RMGIC.

There is no consensus on the microleakage of PMCR, RMGIC, and conventional GIC.[20-24] Microleakage resulting from shrinkage of the resins added to the structure in RMGIC and PMCR during polymerization is problematic.[20,25] The bonding of RMGICs and conventional GICs to dental tissues through ion exchange may reduce microleakage.[26,27]

In the comparative microleakage study performed by Balgi *et al*. with rhodamine B staining method between RMGIC and conventional GIC, no difference was observed.[28] Furthermore, in our study, we did not observe any difference in microleakage between RMGIC and conventional GIC.

RMGIC exhibits less microleakage than PMCR.[21,22] Similarly, PMCR exhibits greater microleakage than RMGIC and PMCR, likely due to the nonapplication of acid to the edges of the enamel and to shrinkage of the PMCR during polymerization.[29]

However, other studies do not support the finding that RMGICs bind more strongly, in particular to dentin tissue, than PMCR. For example, Morabito and Defabianis[23] reported that PMCR had superior edge fitting, esthetic, and mechanical properties than RMGIC. Similarly, Florita *et al*.[30] found the least microleakage in the PMCR group in which acid and primer were applied together and the most microleakage in the RMGIC group. Xie *et al*.[31] compared the microleakage values of flowable composite resin, PMCR, and conventional GIC in class V cavities in permanent premolar teeth. They reported that microleakage was greatest in the conventional GIC group.

The finding that PMCR exhibited less-than-expected microleakage despite its high resin content may be due to the strength of the micromechanical bond formed by acidification and adhesive agents.

The porous structure and microcracked surface of RMGIC enhance microleakage.[7] In addition, air cavities remain in the restoration due to the lack of condensation of RMGICs, which are difficult to manipulate.[23,26] Our data support the notion that the porous structure of RMGIC increases microleakage.

The materials applied in this study are frequently used in dentistry. However, we used a quantitative method rather than the more typical qualitative analysis.[17] AutoCAD allows quantitative evaluation by volume addition[18,19,32] and is a powerful tool.[18,32,33]

In this study, primary teeth restorations using PMCR exhibited less microleakage than RMGIC and high-viscosity GIC restorations. In conclusion, PMCR may be a useful restorative material for primary teeth in terms of minimizing microleakage.

Financial support and sponsorship

This study was supported by Dicle University Scientific Research Projects (project no. 13DH-19).

Conflicts of interest

There are no conflicts of interest.

References

1. Mali P, Deshpande S, Singh A. Microleakage of restorative materials: An *in vitro* study. J Indian Soc Pedod Prev Dent 2006;24:15-8.
2. dos Santos PH, Pavan S, Assunção WG, Consani S, Correr-Sobrinho L, Sinhoreti MA, *et al.* Influence of surface sealants on microleakage of composite resin restorations. J Dent Child (Chic) 2008;75:24-8.
3. Küçükeşmen C, Sönmez H. Microleakage of class-v composite restorations with different bonding systems on fluorosed teeth. Eur J Dent 2008;2:48-58.
4. Hatirli H, Yasa B, Yasa E. Microleakage and penetration depth of different fissure sealant materials after cyclic thermo-mechanic and brushing simulation. Dent Mater J 2018;37:15-23.
5. Sharafeddin F, Feizi N. Evaluation of the effect of adding micro-hydroxyapatite and nano-hydroxyapatite on the microleakage of conventional and resin-modified glass-ionomer cl V restorations. J Clin Exp Dent 2017;9:e242-8.
6. Toledano M, Osorio E, Osorio R, García-Godoy F. Microleakage of class V resin-modified glass ionomer and compomer restorations. J Prosthet Dent 1999;81:610-5.
7. Payne JH 4th. The marginal seal of class II restorations: Flowable composite resin compared to injectable glass ionomer. J Clin Pediatr Dent 1999;23:123-30.
8. Tung FF, Estafan D, Scherer W. Use of a compomer in class V restoration: A microleakage study. Quintessence Int 2000;31:668-72.
9. Erdem AP, Gençay K. Evidence-based clinical recommendations for the use of glass ionomer cements. J Dent Fac Atatürk Univ 2013;23:123-30.
10. McLean JW, Wilson AD. Fissure sealing and filling with an adhesive glass-ionomer cement. Br Dent J 1974;136:269-76.
11. Smith DC. Composition and characteristics of glass ionomer cements. J Am Dent Assoc 1990;120:20-2.
12. Using glass ionomers. Council on dental materials, instruments, and equipment. J Am Dent Assoc 1990;121:181-8.
13. Burke FJ, Fleming GJ, Owen FJ, Watson DJ. Materials for restoration of primary teeth: 2. Glass ionomer derivatives and compomers. Dent Update 2002;29:10-4, 16-7.
14. Singla T, Pandit IK, Srivastava N, Gugnani N, Gupta M. An evaluation of microleakage of various glass ionomer based restorative materials in deciduous and permanent teeth: An *in vitro* study. Saudi Dent J 2012;24:35-42.
15. Croll TP, Nicholson JW. Glass ionomer cements in pediatric dentistry: Review of the literature. Pediatr Dent 2002;24:423-9.
16. Nicholson JW. Polyacid-modified composite resins ("compomers") and their use in clinical dentistry. Dent Mater 2007;23:615-22.
17. De-Deus G. A new dimension in old leakage methods. Int Endod J 2008;41:720-3.
18. Javidi M, Naghavi N, Roohani E. Assembling of fluid filtration system for quantitative evaluation of microleakage in dental materials. Iran Endod J 2008;3:68-72.
19. Cabanillas C, Monterde M, Pallarés A, Aranda S, Montes R. Assessment using autoCAD software of the preparation of dentin walls in root canals produced by 4 different endodontic instrument systems. Int J Dent 2015;2015:517203.
20. Gerdolle DA, Mortier E, Droz D. Microleakage and polymerization shrinkage of various polymer restorative materials. J Dent Child (Chic) 2008;75:125-33.
21. Brackett WW, Gunnin TD, Gilpatrick RO, Browning WD. Microleakage of class V compomer and light-cured glass ionomer restorations. J Prosthet Dent 1998;79:261-3.
22. Uno S, Finger WJ, Fritz UB. Effect of cavity design on microleakage of resin-modified glass ionomer restorations. Am J Dent 1997;10:32-5.
23. Morabito A, Defabianis P. The marginal seal of various restorative materials in primary molars. J Clin Pediatr Dent 1997;22:51-4.
24. Shruthi AS, Nagaveni NB, Poornima P, Selvamani M, Madhushankari GS, Subba Reddy VV, *et al.* Comparative evaluation of microleakage of conventional and modifications of glass ionomer cement in primary teeth: An *in vitro* study. J Indian Soc Pedod Prev Dent 2015;33:279-84.
25. Carvalho RM, Pereira JC, Yoshiyama M, Pashley DH. A review of polymerization contraction: The influence of stress development versus stress relief. Oper Dent 1996;21:17-24.
26. Altay N, Çehreli ZC. Compomers: A potential substitute for resin composites in preventive resin restoration. J Dent Fac Hacettepe Univ 1997;21:52-5.
27. Lloyd CH, Butchart DG. Retention of core composites, glass ionomers, and cermets by a self-threading dentin pin: The influence of fracture toughness upon failure. Dent Mater 1990;6:185-8.
28. Balgi P, Katge F, Pradhan D, Shetty S, Rusawat B, Pol S, *et al.* Comparative evaluation of micro-leakage of two newer glass ionomer cements in primary molars immersed in three beverages: *In vitro* study Ceylon Med J 2017;62:184-8.
29. Oba AA, Aras Ş. A comparison of marginal microleakage of Fuji II LC and F2000 restorations in primary molars, *in vitro*. J Dent Fac Gazi Univ 2003;20:23-8.
30. Florita Z, Haiduc C, Rominu M, Sinescu C, Rominu R, Kigyosi A. Class V compomer restorations: The effect of RMGI primers on microleakage. Eur Cells Mater 2007;13:16.
31. Xie H, Zhang F, Wu Y, Chen C, Liu W. Dentine bond strength and microleakage of flowable composite, compomer and glass ionomer cement. Aust Dent J 2008;53:325-31.
32. Kumar NS, Palanivelu A, Narayanan LL. Evaluation of the apical sealing ability and adaptation to the dentin of two resin-based sealers: An *in vitro* study. J Conserv Dent 2013;16:449-53.
33. Shaikh A, Hegde V, Shanmugasundaram S, Dixit V. A novel approach to construction and working of fluid filtration model: An experimental study. J Sci Innov Res 2017;6:55-8.