

Microleakage of two different posterior composites and a high-viscosity glass-ionomer cement: An in vitro study

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Abstract

Aim: Using AutoCAD, we examined the microleakage of permanent molars in Class I restorations using a conventional posterior composite resin, a bulk-fill composite resin, and a high-viscosity glass-ionomer cement (HVGC).

Methodology: In total, 33 extracted noncarious third molars were used. Class I cavities were prepared. The teeth were randomly divided into three groups of 11 teeth each, as follows: Group A (Filtek Z550), Group B (Filtek Bulk-Fill Posterior Restorative), and Group C (EQUIA Fil). All specimens were stored for 24 h at 37 °C in distilled water. The teeth were thermocycled 1,000 times between 5 ± 2°C and 55 ± 2°C prior to 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.

Results: Statistical evaluations were performed by one-way analysis of variance [ANOVA]. One-way ANOVA showed no significant difference between the three groups in microleakage ($P = 0.07$). However, the lowest microleakage ratio was seen in Group C (EQUIA Fil). Similar results were obtained with all tested materials, but the lowest microleakage rate was obtained with EQUIA Fil (Group C).

Conclusion: In this study, the tested materials were not completely successful in eliminating microleakage, although the lowest microleakage rate was obtained with EQUIA Fil.

Keywords: composite resin, high-viscosity glass-ionomer cement, microleakage, AutoCAD

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Received: 10 October 2021

Accepted: 20 June 2022

Access Online



DOI:

10.5577/intdentres.2022.vol12.no1.6

How to cite this article: Çelenk S, Ataş O, Ayna B, Günay A. Microleakage of two different posterior composites and a high-viscosity glass-ionomer cement: An in vitro study. Int Dent Res 2022;12(1):34-8. <https://doi.org/10.5577/intdentres.2022.vol12.no1.6>

Introduction

Amalgam fillings have been accepted as the most reliable restorative material for nearly two centuries. However, in recent years, attention has focused on the need for a worldwide reduction in the use of mercury. It was decided at the Minamata Convention in Japan 2013, that priority should be given to the development

of alternative dental materials (1). Currently, the restorative materials that can be preferred as alternatives to amalgam are composite resins and glass ionomer-based restorative materials; these can be micromechanically bonded to tooth tissue (2).

Composite resins are frequently used in dentistry because of their good results in adhesive restorations and their aesthetic advantages (3). To improve the

performance and physical properties of composite resins, posterior composite resins have been developed, called “bulk-fill”, which are claimed to be polymerized even at 4-5 mm thickness (4, 5). However, the problems of failure to provide a long-lasting seal between the material and the tooth and polymerization shrinkage of these materials remain (3-5). At the same time, the need for sensitive application techniques and high costs inhibit the use of this alternative material to amalgam in many countries (2).

Glass-ionomer cements (GICs), developed by Wilson and Kent and used since 1972, are less successful than amalgam because of low fracture and wear resistance, dryness, and moisture sensitivity (6,7). High-viscosity GICs (HVGICs) have been developed to improve the mechanical properties of GICs, and their wear resistance to occlusal forces and to expand the indication fields, which are currently limited to Class I and Class V restorations. HVGICs are intended to be a composite resin and alternative restoration material to amalgam (8,9). In these materials, by changing the particle size/distribution and powder/liquid ratio and removing excess calcium ions from the surface of the glass particles, better mechanical properties and wear resistance have been achieved (10). The powder/liquid ratio is 3:1 or 4:1 in GICs, which increases to 6:1 or 7:1 in HVGICs. In the clinic, HVGIC capsules have been developed to ensure the correct powder/liquid ratio (10,11). At the same time, manufacturers have reported that nano-filled resin coating used in combination with this material achieves excellent coverage at the GIC surface, gives

its high hydrophilic and very low viscosity properties (11, 12).

The purpose of this study is to investigate the microleakage of a bulk-fill composite resin, a conventional posterior composite resin, and an HVGIC to class I restorations in permanent molars. The AutoCAD program was used for quantitative analysis of the data.

Materials and Methods

Ethical approval was given for this study by the Ethics Committee of the Faculty of Dentistry of Dicle University, Turkey, on March 06, 2013 (Approval number: 2013-2). A complete of 33 extracted noncarious wisdom teeth were included in this study. After the superficial debris layer was removed with a handpiece, the extracted teeth were kept in a balanced salt solution at 22-24°C. Each tooth was abraded from the occlusal surface to form a surface perpendicular to the long axis of the tooth. Standardized Class I cavities (4 mm buccolingual width, 4 mm mesiodistal width, 4 mm depth) were prepared using a high-speed handpiece with water cooling. The prepared dental samples were randomly separated into three groups of 11 teeth each: Group A (Filtek Z550; 3M ESPE, Seefeld, Germany), Group B (Filtek Bulk-Fill Posterior Restorative; 3M ESPE), and Group C (EQUA Fil; 3M ESPE) (Table 1). The A2 color was chosen as the standard.

Table 1. Descriptions of and manufacturer information for the materials evaluated in this study

Group	Restorative material	Commercial name	Manufacturer
Group A	Conventional posterior composite resin	Filtek Z550	3M ESPE, St. Paul, MN, USA.
Group B	Bulk-fill posterior composite resin	Filtek Bulk-Fill Posterior Restorative	3M ESPE
Group C	High-viscosity glass-ionomer cement	EQUA Fil	GC Co., Tokyo, Japan

Group A. The prepared cavity was engraved with 37.5% phosphoric acid (Scotchbond; 3M ESPE) (30 s enamel and 15 s for dentin), thoroughly immersed in water for 30 s after that, and lightly dried, leaving the surface wet. Universal adhesive (Single Bond Universal; 3M ESPE) was implemented to the cavity and left for 20 s. The adhesive was light-cured for 10 s. Conventional posterior composite resin material was incrementally

applied (2 mm thickness) and polymerized for 20 s from the occlusal surface.

Group B. Firstly, etching and bonding were applied in group A. Bulk-fill posterior composite resin was applied as a single 4-mm-thick layer and polymerized for 20 s from the occlusal surface.

Group C. First, 20% polyacrylic acid (GC Conditioner; GC Co., Tokyo, Japan) was applied to the

cavities for 10 s and then rinsed and gently dried. The EQUIA Fil capsule was activated and mixed for 10 s in accordance with the manufacturer's instructions. The material was injected into cavities within 10 s with a metallic applicator. After setting for 2.5 min according to the manufacturer's instructions, the GIC was briefly dried, covered with a nano-filled resin coating material (Equia Coat; GC Co.), and cured for 20 s from the occlusal surface.

A light-emitting diode (LED) light-curing unit (DB-685; Coxo Co., Shishan Town, China) with a light intensity of 1,600 mW/cm² was used for all curing procedures. All preparative and restorative procedures were performed by the same operator.

The samples were kept in distilled water for 24 hours at 37 ° C. Later, all samples were subjected to thermal cycles between 5 ± 2 ° C and 55 ± 2 ° C 1000 times.

After the root apexes of all teeth were covered with composite resin, all surfaces were covered with nail polish, 1mm away from the restoration edges. The samples soaked in 0.5% basic fuchsin were washed after 24 hours. All specimens were embedded in acrylic resins (Temdent; Schütz Dental, Rosbach vor der Höhe, Germany). Then it was divided into two sections in the buccolingual direction with a precision cutting machine (IsoMet; Buehler Ltd., Lake Bluff, IL, USA). Dye

infiltrated surface area was measured using AutoCAD 2016 software (Autodesk Inc., San Rafael, CA, USA) after examinations were performed at x40 magnification by stereomicroscope (S8 APO; Leica Microsystems, Taipei, Taiwan) for microleakage assessment.

Statistical analysis

To statistically evaluate the results, R software (ver. 3.2.3; R Development Core Team, Vienna, Austria) was used. Statistical evaluations were done by one-way analysis of variance [ANOVA], and a 95% ($p < 0.05$) confidence interval was applied.

Results

The mean ± standard deviation microleakage values are presented in Table 2. One-way ANOVA was performed to assess differences in microleakage among the three groups; no significant differences were found ($P = 0.07$) (Table 3). However, the highest microleakage ratio was seen in Group A (Filtek Z550), followed by Group B (Filtek Bulk-Fill Posterior Restorative), and Group C (EQUIA Fil) (Figure 1).

Table 2. Microleakage values of the tested materials

Group	No. of samples	Mean microleakage area	Standard deviation
Group A (Filtek Z550)	22	0.00478	0.00368
Group B (Filtek Bulk-Fill Posterior Restorative)	22	0.00342	0.00302
Group C (EQUIA Fil)	22	0.00227	0.00381

Table 3. Microleakage ratios of the tested materials

	Group A	Group B	Group C
Microleakage ratio	0.00478	0.00342	0.00227
Group A, Filtek Z550; Group B, Filtek Bulk-Fill Posterior Restorative; Group C, EQUIA Fil. F = 2.77; p = 0.07			

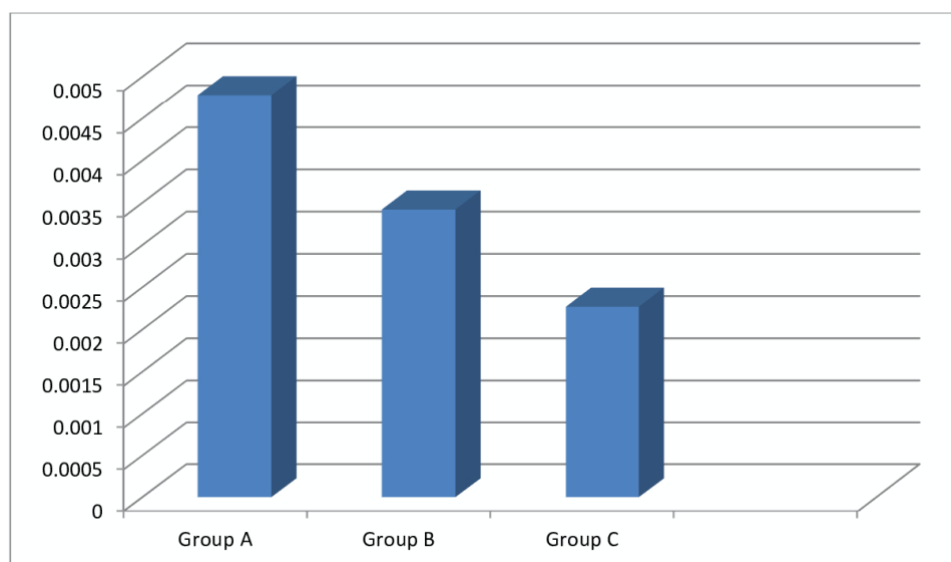


Figure 1. Mean microleakage values of the tested materials.
Group A, Filtek Z550; Group B, Filtek Bulk-Fill Posterior Restorative; Group C, EQUIA Fil.

Discussion

With the adoption of modern therapeutic approaches, expectations for dental materials have also increased. Patient-centered, preventive, and minimally invasive approaches have rendered the choice of restorative materials controversial (2). Accordingly, dentists must examine manufacturers' claims and the literature to determine the materials and techniques that best serve the patient.

The most reliable method to assess the effectiveness of a material is via clinical studies, but such studies are time-consuming and difficult to standardize. Microleakage is among the effective factors in determining the clinical life of restorative materials. Microleakage tests, which are generally analyzed with subjective evaluations, are important in determining how leakage the material is and in terms of providing information about the coverage offered by the material (13-15). However, the AutoCAD program, which quantitatively measures microleakage, offers an objective volume calculation (16, 17). Therefore, we used AutoCAD to quantitatively evaluate all leakage occurring at the edges of the restorations. We also applied the dying method, which is typically used to detect microleakage (15-17). The samples were first thermocycled to imitate clinical conditions. Then, the depth of dye penetration at the restoration interface of the tooth was determined by AutoCAD.

It has been claimed that EQUIA Fil, a HVGIC that has been used in recent studies, performs similarly to amalgam, even in Class I and II restorations of permanent teeth. HVGICs, which have the same hardening mechanisms as GICs, show increased wear resistance, surface hardness, flexural and compressive strength, and reduced solubility (12). Moreover, their physical properties have been optimized via nano-filled resin coatings (2, 11, 12). However, no study has

directly compared the performance of amalgam and HVGICs; most previous studies were on the composite resins that are frequently used at present for the restoration of posterior teeth. For this reason, a conventional posterior composite resin and a bulk-fill composite resin were used in this study to evaluate the microleakage performance of EQUIA Fil, a HVGIC.

There is no statistically significant difference in terms of microleakage between the materials used in the study. However, microleakage values from lowest to highest are respectively HVGIC (Group C), bulk-fill posterior composite resin (Group B), and conventional posterior composite resin (Group A).

Castro and Feigal found no significant difference in microleakage between HVGIC and composite resin restorations in in vitro microleakage studies on primary and permanent teeth (18). Yikilgan et al. obtained similar results in their studies of HVGIC and composite resin restorations (19). Gopinath also found no significant difference in microleakage between HVGIC and bulk-fill composite resin (20). Kalmowicz obtained similar results in a study comparing composite resin (incremental fill) and bulk-fill composite resin (21). The results of the above studies support our findings.

The lower rate of microleakage seen in the EQUIA Fil samples in our study may be related to the nano-filled resin coating on the restoration surface and its favorable physicochemical properties. It is believed that the increase in temperature that occurs during light-curing of the resin coating enhances the mechanical properties of the auto-cured HVGIC material (22); it has been claimed that this contributes to the maturation of the material and reduces the amount of microleakage (23). Furthermore, survival rates of up to 100% have been observed in many studies evaluating the clinical success of restorations performed with the HVGIC/resin coating combination (2, 24, 26).

Conclusions

In this study, the tested materials were not completely successful in eliminating microleakage, although the lowest microleakage rate was obtained with EQUIA Fil (Group C). It appears that the combination of HVGIC plus resin coating offers a viable alternative to amalgam fillings for patients and can enhance patient and environmental health. In addition, the need for fewer application procedures when using EQUIA Fil, and the reduced treatment time, are especially advantageous in pediatric dentistry, where younger patients can become easily agitated.

Ethical Approval: Ethics committee approval was received for this study from Dicle University, Faculty of Dentistry Ethics Committee, in accordance with the World Medical Association Declaration of Helsinki, with the approval number: 2013/2).

Peer-review: Externally peer-reviewed.

Author Contributions: Conception - S.Ç.; Design - O.A., B.A.; Supervision - A.G.; Materials - S.Ç., O.A.; Data Collection and/or Processing - B.A., A.G.; Analysis and/or Interpretation - S.Ç.; Literature Review - O.A., B.A.; Writer - A.G.; F.H.; Critical Review - S.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

References

1. UNEP (United Nations Environmental Programme). Minamata Convention on Mercury. Available at: <http://www.mercuryconvention.org>.
2. Kielbassa AM, Glockner G, Wolgin M, Glockner K. Systematic review on highly viscous glass-ionomer cement/resin coating restorations (Part I): Do they merge Minamata Convention and minimum intervention dentistry? *Quintessence Int* 2016;47:813-823.
3. Lynch CD, Opdam NJ, Hickel R, Brunton PA, Gurgan S, Kakaboura A, Shearer AC, Vanherle G, Wilson NH. Guidance on posterior resin composites: Academy of Operative Dentistry - European Section. *J Dent* 2014;42(4):377-383. (Crossref)
4. Park J, Chang J, Ferracane J, Lee IB. How should composite be layered to reduce shrinkage stress: incremental or bulk filling. *Dent Mater* 2008;24:1501-1505. (Crossref)
5. Vasquez D. A new generation bulk fill composite for direct posterior restorations. *Inside Dentistry* 2012;8:5.
6. McLean J, Wilson A. The clinical development of the glass ionomer cement. II. Some clinical applications. *Aust Dent J* 1977;22:120-127. (Crossref)
7. Ilie N, Hickel R, Valceanu AS, Huth KC. Fracture toughness of dental restorative materials. *Clin Oral Investig* 2012;16(2):489-498. (Crossref)
8. Gurgan S, Kutuk ZB, Ergin E, Oztas SS, Cakir FY. Four-year randomized clinical trial evaluate the clinical performance of a glass ionomer restorative system. *Oper Dent* 2015;40:134-143. (Crossref)
9. Mickenautsch S, Yengopal V. Direct contra naïve-indirect comparison of clinical failure rates between high-viscosity GIC and conventional amalgam restorations: An empirical study. *PLoS One* 2013;8(10):e78397. (Crossref)
10. Basting RT, Serra MC, Rodrigues AL. In situ microhardness evaluation of glass-ionomer/composite resin hybrid materials at different post-irradiation times. *J Oral Rehabil* 2002; 29:1187-1195. (Crossref)
11. Crowley CM, Doyle J, Towler MR, Hill RG, Hampshire S. The influence of capsule geometry and cement formulation on the apparent viscosity of dental cements. *J Dent* 2006;34:566-573. (Crossref)
12. Friedl K, Hiller KA, Friedl KH. Clinical performance of a new glass ionomer based restoration system: a retrospective cohort study. *Dent Mater* 2011;27(10):1031-1037. (Crossref)
13. Mali P, Deshpande S, Singh A. Microleakage of restorative materials: an in vitro study. *J Indian Soc Pedod Prev Dent* 2006;24(1):15-18. (Crossref)
14. Gerdolle DA, Mortier E, Droz D. Microleakage and polymerization shrinkage of various polymer restorative materials. *J Dent Child* 2008;75(2):125-133.
15. De-Deus G. A new dimension in old leakage methods. *Int Endod J* 2008;41:720-723. (Crossref)
16. Javidi M, Naghavi N, Roohani E. Assembling of fluid filtration system for quantitative evaluation of microleakage in dental materials. *Iran Endod J* 2008;3(3):68-72.
17. 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 (1-5). (Crossref)
18. Castro A, Feigal RE. Microleakage of a new improved glass ionomer restorative material in primary and permanent teeth. *Pediatr Dent* 2002;24:23-28.
19. Yıkılğan I, Akgül S, Özcan S, Bala O, Ömürlü H. An in vitro evaluation of the effects of desensitizing agents on microleakage of Class V cavities. *J Clin Exp Dent* 2016;8:55-59. (Crossref)
20. Gopinath V. Comparative evaluation of microleakage between bulk esthetic materials versus resin-modified glass ionomer to restore Class II cavities in Primary Molars. *J Indian Soc Pedod Prev Dent* 2017;35:238-243. (Crossref)
21. Kalmowicz J, Phebus JG, Owens BM, Johnson WW, King GT. Microleakage of Class I and II composite resin restorations using a sonic-resin placement system. *Oper Dent* 2015;40:653-661. (Crossref)
22. Molina GF, Cabral RJ, Mazzola I, Brain Lascano L, Frencken JE. Biaxial flexural strength of high-viscosity glass-ionomer cements heat-cured with an LED lamp during setting. *BioMed Res Int* 2013;2013:838460 (1-6). (Crossref)
23. Dehurtevent M, Deveaux E, Hornez JC, Robberecht L, Tabary N, Chai F. Influence of heat and ultrasonic treatments on the setting and maturation of a glass-ionomer cement. *Am J Dent* 2015;28(2):105-110.
24. Diem VT, Tyas MJ, Ngo HC, Phuong LH, Khanh ND. The effect of a nano-filled resin coating on the 3-year clinical performance of a conventional high-viscosity glass-ionomer cement. *Clin Oral Investig* 2014;18(3):753-759. (Crossref)
25. Gurgan S, Kutuk ZB, Ergin E, Oztas SS, Cakir FY. Four-year randomized clinical trial to evaluate the clinical performance of a glass ionomer restorative system. *Oper Dent* 2015;40(2):134-143. (Crossref)
26. Kielbassa AM, Glockner G, Wolgin M, Glockner K. Systematic review on highly viscous glass-ionomer cement/resin coating restorations (Part II): Do they merge Minamata Convention and minimum intervention dentistry? *Quintessence Int* 2017;48(1):9-18.