Microleakage Evaluation of Class V Restorations with Conventional and Resin-modified Glass Ionomer Cements

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Abstract

The aim of this study was to evaluate *in vitro* the marginal microleakage of conventional Glass Ionomer Cements (GIC) and Resin Modified Glass Ionomer Cements (RMGIC). The tested materials were grouped as follows: GIC category – G1 (Vidrion R – SSWhite); G2 (Vitro Fill – DFL); G3 (Vitro Molar – DFL); G4 (Bioglass R – Biodinâmica); and G5 (Ketac Fill – 3M/ESPE); and RMGIC category – G6 (Vitremer – 3M/ESPE); G7 (Vitro Fill LC – DFL); and G8 (Resiglass – Biodinâmica). Therefore, 80 class V cavities (2.0X2.0 mm) were prepared in bovine incisors, either in the buccal face. The samples were randomly divided into 8 groups and restored using each material tested according to the manufacturer. The root apices were then sealed with acrylic resin. The teeth were stored for 24 h in 100% humidity at 37°C. After storage, the specimens were polished with extra-slim burs and silicon disc (Soft-lex – 3M/ESPE), then were isolated with cosmetic nail polish up to 1 mm around the restoration. Then, the samples were immersed in 50% $AgNO_3$ solution for 12 h and in a developing solution for 30 min. They were rinsed and buccal-lingual sectioned. The evaluation of the microleakage followed scores from 0 to 3. The Kruskal-Wallis test and Dunn method test were applied (α=0.05). The results showed that there was no difference between the enamel and dentin margins. However, GIC materials presented more microleakage than RMGIC.

Key words: Enamel, Dentin, Glass ionomer cements, Resin-modified glass ionomer cements, Microleakage

Introduction

Since their introduction by Wilson and Kent in the late 1970s, conventional Glass Ionomer Cements (GIC) have been applied worldwide due to favorable characteristics such as chemical adhesion, limited cure shrinkage, fluoride release, and thermal properties similar to dental tissues [1]. However, inconvenient setting characteristics, fragility, and a less-than-ideal appearance have limited the acceptance of these materials [2]. In order to overcome such limitations, hybrid versions were introduced, such as the Resin-modified Glass Ionomer Cement (RMGIC) [3].

Different studies have shown that the RMGIC are more effective than the conventional GIC on the marginal sealing [4,5]. However, the composition of each cement may vary between different manufacturers and different results are expected when a variety of brands are tested [3,6]. In the absence of clinical data, laboratory microleakage studies are a well-accepted method of screening adhesive restorative materials for adequate marginal adaptation [6,7].

According to Nakabayashi and Pashley, microleakage is defined as the passage of fluids and substances through minimal gaps on the interface restoration-teeth [8]. In theory, microleakage is deemed as an indication of failure because it reduces the sealing's effectiveness, compromises the restoration, and increases the chances of secondary caries and post-operative sensibility [8].

Due to the increasing number of cements arriving on the scene every year, as well as the absence of published papers concerning its physical properties, the aim of this study was to evaluate the *in vitro* microleakage, into class V restorations, with conventional Glass Ionomer Cement (GIC) and Resin-modified Glass Ionomer Cement (RMGIC). The null hypothesis of this study is that there is no difference, regarding microleakage, to use GIC or RMGIC in cavities with or without enamel at the cavosurface margin.

Materials and Methods

The selected materials tested on this study are shown in *Table 1*. The tested materials included five GIC and three RMGIC. Sixty bovine incisors previously stored in distilled water at -6ºC were selected and defrosted at 25ºC. Then, the incisors were evaluated under an x10 magnifying glass to check the presence of cracks or fractures on the enamel. The 40 best incisors were selected and 80 circular class V cavities, 2 x 2 x 2 mm, were prepared with a spherical (#6) carbide burn (KG Sorensen, Cotia, SP, Brazil) under refrigeration at the cementoenamel junction, so that the upper margins were in enamel and the lower margins were in dentin/cement. Class V cavities were located in the vestibular and lingual faces. After the preparation, the cavities were rinsed with distilled water and carefully dried using absorbent paper to avoid dehydration.

The samples were randomly divided into 8 groups (n=10) and restored using each material tested according to the manufacturer. A needled syringe tip (Centrix – DFL, Rio de Janeiro, Brazil) was used to place each of the cement in the cavities in order to avoid the inclusion of air. The light curing of the RMGIC was performed with a continuous mode, 475 nm length wave and 1200 mW/cm^2 light intensity using a LED unit (Radii – SDI, Sydney, Australia) and an unfilled penetrating resin was used as a superficial protection agent

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(SPA – Fortfy™, Bisco, Schaumburg, IL, USA) to protect the restoration.

The root apices were then sealed with acrylic resin. For 24 h, the teeth were stored in 100% humidity at 37°C simulating the oral environment and expecting the initial curing process. After storage, the specimens were finishing and polished using ultra-fine diamond burs and aluminum oxide discs (Sof-Lex - 3M/ESPE, Irvine, CA, USA), ranging from coarse to superfine respectively and isolated with cosmetic nail polish up to 1 mm around the restoration. Then, the samples were immersed in a contrast solution of 50% silver nitrate ($AgNO_3$) for 12 h using a dark container and immersed in a developing solution for 30 minutes in strong fluorescent light.

Finally, the specimens were rinsed with distilled water and vertically sectioned through the center of the restorations using diamond discs (KG Sorensen, Cotia, SP, Brazil) under refrigeration. Only the left half of each sample was used during the evaluation. Three previously calibrated evaluators analyzed each half of the specimens under an x10 magnifying glass, for microleakage of silver along both the occlusal and gingival margins. The scoring method was (*Figure 1*):

0 - no dye penetration;
1- Silver nitrate penetrating up to 1 mm deep;
2 - Silver nitrate penetrating beyond 1mm deep;
3 - Silver penetrating beyond pulp wall [9].

A score for each margin was determined in consensus after evaluation and discussions. In case of doubts, the higher score prevailed. Statistical analyses were carried out with the Kruskal-Wallis test and the Dunn method for 2x2 significance (α=0.05).

Results

The restorative cements evaluated in this study are described in *Table 1*. The results of the occlusal (enamel) and cervical (dentin) margins microleakage are shown in *Tables 2 and 3*, respectively. In the occlusal (enamel) margin, G1 presented the worst microleakage rate, with significant differences only for G5 (GIC) (p=0.025), G6 (RMGIC) (p=0.008), and G7 (RMGIC) (p=0.011). Moreover, G6 (RMGIC) achieved the best results with statistically significant difference from the GIC groups, except from G5 (p=0.075). In the dentinal margin, there was no significant difference among the GIC groups (p=0.132). However, G6 showed the lower microleakage rate with significant difference from all other groups ($p<0.05$).

Considering the type of cement factor, RMGIC cements achieved the lower microleakage rates with significant difference from GIC materials (*Figure 2*). Furthermore, when comparing the cervical (dentin) and occlusal (enamel) margin factors, there is no significant difference between them (*Figure 3*).

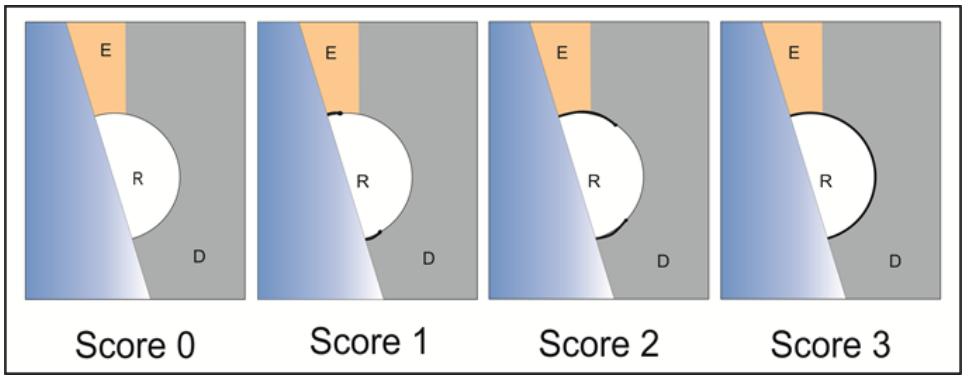

***Figure 1**. Score schematic representation. E: enamel, R: restoration, D: dentin. Score 0: no visible silver penetration; Score 1: silver nitrate penetrating up to 1mm deep; Score 2: silver nitrate penetrating beyond 1mm deep; Score 3: silver penetrating beyond pulp wall.*

***Table 1**. List of adhesives restoratives cements tested.*

Group	Materials	Composition	Manufacturer
1	**Vidrion R (GIC)**	**Powder:** Sodium calcium aluminum fluorosilicate, barium sulfate, polyacrylic acid and pigments. **Liquid:** tartaric acid, distilled water.	(S.S.White - Rio de Janeiro, Brazil)
2	**Vitro Fill (GIC)**	**Powder:** Strontium aluminum silicate, dehydrated polyacrylic acid and iron oxide. **Liquid:** Polyacrylic acid, tartaric acid and distilled water.	(DFL - Rio de Janeiro, Brazil)
3	**Vitro Molar (GIC)**	**Powder:** Barium aluminum silicate, dehydrated polyacrylic acid and iron oxide. **Liquid:** Polyacrylic acid, tartaric acid and distilled water.	(DFL - Rio de Janeiro, Brazil)
4	**Bioglass R (GIC)**	**Powder:** Calcium Barium and Aluminum Fluorosilicate, Polyacylic acid and inorganic fillers. **Liquid:** Polyacrylic acid, tartaric acid and deionized water.	(Biodinâmica - Ibiporã, Brazil)
5	**Ketac-Fill (GIC)**	**Powder:** Lanthanum, Aluminum and Strontium Fluorosilicate glass, pigments. **Liquid:** tartaric acid and water.	(3M/ESPE - Neuss, Germany)
6	**Vitremer (RMGIC)**	**Powder/Liquid:** Methacrylate polyacids, water, Aluminum Fluorosilicate glass, methacrylate monomers and initiators.	(3M/ESPE - Neuss, Germany)
7	**Vitro Fill LC (RMGIC)**	**Powder:** Strontium aluminum silicate, excipients, activators and iron oxide. **Liquid:** 2-Hydroxyethyl methacrylate polyacids, stabilizer, catalyzer and ethyl alcohol.	(DFL - Rio de Janeiro, Brazil)
8	**Resiglass R (RMGIC)**	**Powder:** Calcium Barium and Aluminum Fluorosilicate, Polyacrylic acid and inorganic filers. **Liquid:** Dimethacrylates groups, deionized water and catalyst..	(Biodinâmica - Ibiporã, Brazil)

GIC: Glass Ionomer Cement; RMGIC: Resin-modified Glass Ionomer Cement.

***Table 2**. Mean rank for the occlusal (enamel) margin with the Kruskal-Wallis test (p<0.01) and the Dunn method for 2x2 significance (p<0.05).*

Group	Material	Rank	Significance level* (p<0.05)			
G1	Vidrion R (GIC)	67,9	**a**			
G2	Vitro Fil (GIC)	59,8	**a**	**b**		
G4	Bioglass R (GIC)	52,15	**a**	**b**		
G3	Vitro Molar (GIC)	49,01	**a**	**b**	**c**	
G8	Resiglass R Restore (RMGIC)	39,55	**a**	**b**	**c**	**d**
G5	Ketac Fil (GIC)	28,81		**b**	**c**	**d**
G7	Vitro Fill LC (RMGIC)	15,6			**c**	**d**
G6	Vitremer (RMGIC)	11,2				**d**

* Level of significance: different letters represent statistical difference among groups.
GIC: Glass Ionomer Cement; RMGIC: Resin-modified Glass Ionomer Cement.

***Table 3**. Mean rank for the cervical (dentin) margin with the Kruskal-Wallis test (p<0.01) and the Dunn method for 2x2 significance (p<0.05).*

Group	Material	Rank		Significance level* (p<0.05)									
G1	Vidrion R (GIC)	67,9		**a**									
G2	Vitro Fill (GIC)	59,8		**a**									
G4	Bioglass R (GIC)	52,15		**a**		**b**							
G3	Vitro Molar (GIC)	49		**a**		**b**		**c**					
G8	Resiglass R Restore (RMGIC)	39,55		**a**		**b**		**c**		**d**			
G5	Ketac Fill (GIC)	28,8		**a**		**b**		**c**		**d**			
G7	Vitro Fill LC (RMGIC)	15,6				**b**		**c**		**d**			
G6	Vitremer (RMGIC)	11,2										**e**	

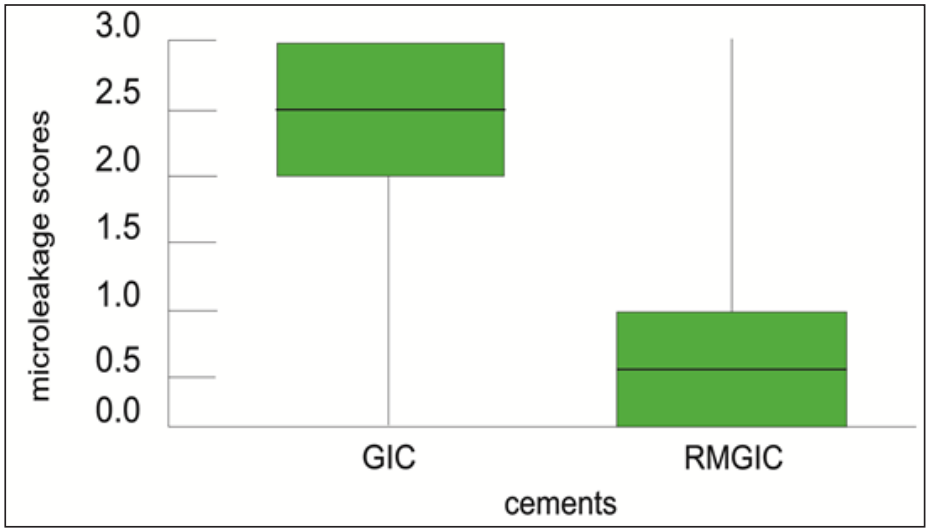

***Figure 2**. Box-Plot diagram comparing the GICs and RMGICs (Mann-Whitney, p<0.05).*

Discussion

In spite of all achieved progress of the restorative dentistry, microleakage is still an undesirable possibility and it appears to be very hard to eliminate [3,6,8-11]. The chase for a perfect adhesion between dental tissues and the restorative materials is the gear lever for new researches on adhesive restorative materials.

Microleakage has been explored widely in the literature [12–15].Additionally, it is well known that the cavities restored with glass ionomer cements present good marginal sealing [2,11,16]. However, different results are expected using materials with a variety of components [2,6]. In this case, the study of microleakage contributes to a better understanding of the physical properties of different materials.

The methodology was determined after the evaluation of the literature. The variety of methodologies usually culminates to a visual detection and the use of a score system [10,11,14,17]. Bovine incisors were used in the study due to their similarity to human teeth [9,18,19]. While bovine teeth tend to slightly increase the incidence of microleakage [10], they are still considered a good substitute when human teeth are unavailable [6].

The utilization of a Superficial Protection Agent (SPA) in two steps – one after the material insertion and the second after polishing – presented in the methodology of some articles, was analyzed in the pilot tests [3,17]. It showed that those who received double layers of the SPA presented less microleakage than those with a single application. During the visual analysis, the evaluators verified that on those specimens with double layers, the margins where the SPA did not reach the microleakage was similar to those with a single layer. Therefore, it was established that the use of a second SPA application on the surface of the restoration, after the polishing, would influence the final results. The single appliance of an SPA is justified by the possibility of alterations (such as dehydration or water absorption) in the cement, especially in the first 24 hours. Therefore, an SPA – a fluid luting monomer – was applied in a single layer during the test only after the insertion of the tested cements in the cavities, and this cover material was removed during

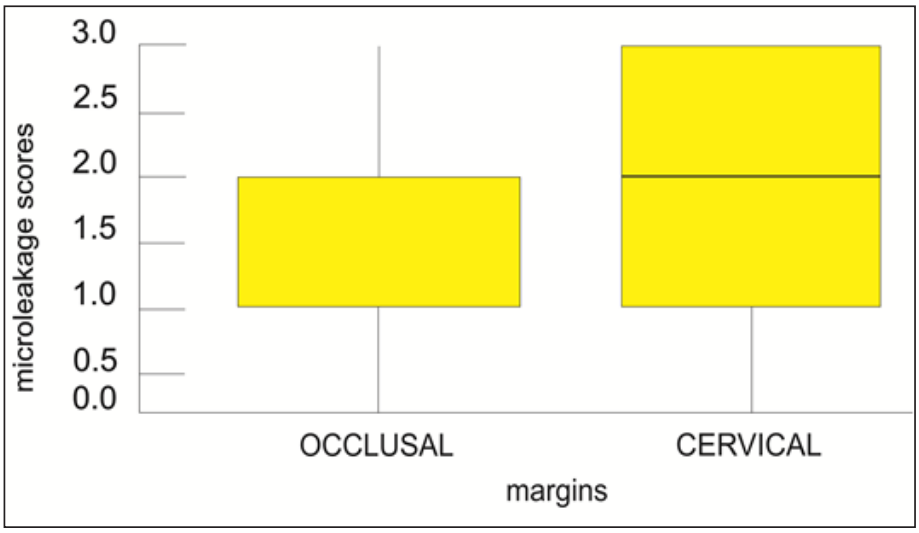

Figure 3. *Box-Plot diagram comparing the evaluated margins (Mann-Whitney, p>0.05).*

the polishing procedure. Even though resin-modified glass ionomer cements can be finished immediately, they remain moisture sensitive and a surface protection should be used to reduce margin microleakage of resin-modified glass ionomer restorations [6].

The GIC showed more leakage than the RMGIC, supporting the results of other studies [4,5]. The addition of resin components and initiators in the RMGIC increased the *in vitro* and *in vivo* performance of those materials, resulting in products with better restorative properties, enlarging its clinical appliance [20,21]. The Resin-modified Glass Ionomer Cement (RMGIC) shows a controlled cure process due to the addition of resin components, being more comfortable to the operator, as the short manipulation time of the conventional Glass Ionomer Cement (GIC) has been a problem [22].

The cervical margins presented a larger amount of microleakage, which is in accordance with the common knowledge that the adhesion on enamel is more effective than on dentin, as they present particularities on its composition [23]. The enamel shows a major prismatic and non-organic composition and the dentin presents a more complex organization, with more organic components and a dynamic character due to the presence of the tubules in the interior of its structure [24]. A restorative system, which seals equally the enamel and dentin, has yet to be developed.

The difficulty of collecting published articles that include the tested cements, as well as the variety of methodologies presented in the literature, made a comparative analysis of the results difficult. However, according to our results, when the clinician is faced with class V cavities, a RMGIC restoration may be a better option than conventional GIC. Thus, it is worth noting that this was an *in vitro* study, and other clinical factors besides the microleakage may also contribute to the success of such restorations.

Conclusions

Within the limitations of this *in vitro* study, we may conclude that:

- The conventional GIC groups showed significantly more leakage than the RMGIC groups. However, the best cement in avoiding microleakage of the GIC groups (G5 – Ketac Fill; 3M/ESPE) did not differ statistically from the worst cement of the RMGIC group (G8 – Resiglass; Biodinâmica).
- The microleakage at the cervical (dentin) margin was not statistically different to the occlusal (enamel) margin.

References

1. Burke FJ. Dental materials—what goes where? The current status of glass ionomer as a material for loadbearing restorations in posterior teeth. *Dental Update*. 2013; **40**: 840-844.

2. Sidhu SK. Glass-ionomer cement restorative materials: a sticky subject? *Australian Dental Journal*. 2011; **56**: 23-30.

3. Lucas ME, Arita K, Nishino M. Toughness, bonding and fluoride-release properties of hydroxyapatite-added glass ionomer cement. *Biomaterials*. 2003; **24**: 3787-3794.

4. Brackett WW, Gunnin TD, Johnson WW, Conkin JE. Microleakage of light-cured glass-ionomer restorative materials. *Quintessence International*. 1995; **26**: 583-585.

5. Bouschlicher MR, Vargas MA, Denehy GE. Effect of desicattion on microleakage of five class 5 restorative materials. *Operative Dentistry*. 1996; **21**: 90-95.

6. Farmer SN, Ludlow SW, Donaldson ME, Tantbirojn D, Versluis A. Microleakage of composite and two types of glass ionomer restorations with saliva contamination at different steps. *Pediatric Dentistry*. 2014; **36**: 14-17.

7. Khoroushi M, Karvandi TM, Komali B, Mazaheri H. Marginal microleakage of resin-modified glass-ionomer and composite resin restorations: effect of using etch-and-rinse and self-etch adhesives. *Indian Journal of Dental Research*. 2012; **23**: 378-383.

8. Nakabayashi N, Pashley DH. Hybridization of Dental Hard Tissues. Tokyo: Quintessence Books, 1998; pp. 129-130.

9. Pontes DG, de Melo AT, Monnerat AF. Microleakage of new all-in-one adhesive systems on dentinal and enamel margins. *Quintessence International*. 2002; **33**: 136-139.

10. Erdilek N, Ozata F, Sepetcioglu F. Microleakage of glass ionomer cement composite resin and glass ionomer cement. *The Journal of Clinical Pediatric Dentistry*. 1997; **21**: 311-314.

11. Reis AF, Giannini M, Kavaguchi A, Soares CJ, Line SR. Comparison of a microtensile bond strength to enamel and dentin of human, bovine and porcine teeth. *Journal of Adhesive Dentistry*. 2004; **6**: 117-121.

12. Abuabara A, Santos AJ, Aguiar FH, Lovadino JR. Evaluation of microleakage in human, bovine and swine enamels. *Brazilian Oral Research*. 2004; **18**: 312-316.

13. Köprülü H, Gürgan S, Önen A. Marginal seal of a resin-modified glass-ionomer restorative material: an investigation of placement techniques. *Quintessence International*. 1995; **26**: 729-732.

14. Sjödin L, Uusitalo M, van Dijken J. Resin modified glass ionomer cements. In vitro microleakage in direct class V and class II sandwich restorations. *Swedish Dental Journal*. 1996; **20**: 77-86.

15. Perdigão J, Dutra-Corrêa M, Saraceni SH, Ciaramicoli MT, Kiyan VH. Randomized clinical trial of two resin-modified glass ionomer materials: 1-year results. *Operative Dentistry*. 2012; **37**: 591-601.

16. Puckett AD, Fitchie JG, Bennet B, Hembree JH. Microleakage and thermal properties of hybrid ionomer restoratives. *Quintessence International*. 1995; **26**: 577-581.

17. Brackett WW, Gunnin TD, Gilpatrick RO, Browning WD. Microleakage of class V compomer and light-cured glass ionomer restorations. *Journal of Prosthetic Dentistry*. 1998; **79**: 261-263.

18. Almeida KG, Scheibe KG, Oliveira AE, Alves CM, Costa JF. Influence of human and bovine substrate on the microleakage of two adhesive systems. *Journal of Applied Oral Science*. 2009; **17**: 92-96.

19. Yavuz I, Tumen EC, Kaya CA, Dogan MS, Gunnay A, Unal M, Toptanci IR, Bahsi E. The reliability of microleakage studies using dog and bovine primary teeth instead of human primary teeth. *European Journal of Paediatric Dentistry*. 2013; **14**: 42-46.

20. Perdigão J, Dutra-Corrêa M, Saraceni SHC, Ciaramicoli MT, Kiyan VH. Randomized clinical trial of two resin-modified glass ionomer materials: 1-year results. *Operative Dentistry*. 2012; **37**: 591-601.

21. Yap AU, Yap WY, Yeo EJ, Tan JW, Ong DS. Effects of finishing/polishing techniques on microleakage of resin-modified glass ionomer cement restorations. *Operative Dentistry*. 2003; **28**: 36-41.

22. Heintze SD & Roulet JF. Glass ionomer derivates have better retention rates in cervical restorations compared to self-etching systems. *Journal of Evidence Based Dental Practice*. 2010; **10**: 18-20.

23. Bayrak S, Sen TE, Tuloglu N. The effects of surface pretreatment on the microleakage of resin-modified glass-ionomer cement restorations. *Journal of Clinical Pediatric Dentistry*. 2012; **36**: 279-284.

24. Perdigão J. Dentin bonding-variables related to the clinical situation and the substrate treatment. *Dental Materials*. 2010; **26**: 24-37.