Pesqui Odontol Bras
v. 15, n. 4, p. 277-282, out./dez. 2001.

Dentística

In vitro quantitative evaluation of marginal microleakage in class II restorations confected with a glass ionomer cement and two composite resins†

Avaliação quantitativa in vitro *da microinfiltração marginal em restaurações classe II, confeccionadas com um cimento de ionômero de vidro e duas resinas compostas*

Maria Fernanda Borro BIJELLA*
Maria Francisca Thereza Borro BIJELLA**
Salete Moura Bonifácio da SILVA***

BIJELLA, M. F. B.; BIJELLA, M. F. T. B.; SILVA, S. M. B. da. *In vitro* quantitative evaluation of marginal microleakage in class II restorations confected with a glass ionomer cement and two composite resins. **Pesqui Odontol Bras**, v. 15, n. 4, p. 277-282, out./dez. 2001.

This study evaluated, *in vitro*, marginal microleakage in class II restorations confected with the glass ionomer cement Vitremer and with the composite resins Ariston pHc and P-60. The aims of the study were to assess the effect of thermocycling on those materials and to evaluate two methods utilized in the analysis of dye penetration. Sixty premolars divided in three groups were utilized; the teeth had proximal cavities whose cervical walls were located 1 mm below the cementoenamel junction. Half of the test specimens from each group underwent thermocycling; the other half remained in deionized water, at 37°C. The specimens were immersed, for 24 hours, in a basic 0.5% fuchsin solution at 37°C. For the analysis of microleakage, the specimens were sectioned in a mesio-distal direction, and the observation was carried out with the software Imagetools. The results were evaluated through the 2-way ANOVA and through the Tukey's test. All groups presented marginal microleakage. The smallest values were obtained with Vitremer, followed by those obtained with the composite resins P-60 and Ariston pHc. There was no statistically significant difference caused by thermocycling, and the method of maximum infiltration was the best for detecting the extension of microleakage.

UNITERMS: Dental leakage; Composite resins; Glass ionomer cements.

INTRODUCTION

Over the past years, aesthetical restorative dentistry has shown considerable progress, leading to the development of countless improved restoring materials for posterior teeth. Currently, the main concerns regarding the performance of these materials refer to their durability and to the integrity of marginal sealing[13], especially in cavities that involve the cement region, where clinical problems are aggravated[18].

Many studies have evaluated the microleakage of different materials[1,3,4,5,7,9,17,19,21,24,27], suggesting modifications in the materials themselves and in the restorative techniques, in an attempt to solve this problem and increase the life span of restorations.

Resin-modified glass ionomer cements are some of the most utilized dental materials in pedodontics. Besides their adhesive properties, these hybrid systems present fluoride release, biocompatibility and reduced syneresis and absorption, with enhanced control of the working time due to their photochemically activated resinous component[20,26], being regarded as some of the best materials for the suppression of microleakage[6].

Up to now, their low resistance to compression and tension contraindicates their utilization in the proximal surfaces of posterior teeth[20]. That stimu-

† Part of Dissertation for the obtainment of Master Degree.
* Graduate Student, School of Dentistry of Bauru - USP.
** Associate Professor; ***PhD – Department of Pedodontics, School of Dentistry of Bauru - USP.

BIJELLA, M. F. B.; BIJELLA, M. F. T. B.; SILVA, S. M. B. da. *In vitro* quantitative evaluation of marginal microleakage in class II restorations confected with a glass ionomer cement and two composite resins. **Pesqui Odontol Bras**, v. 15, n. 4, p. 277-282, out./dez. 2001.

lates the research on materials that surpass the glass ionomer without losing its excellent properties.

Manufacturers have developed an aesthetically restorative material that can be accommodated within the dental cavity, for the confection of class I or class II restorations, which they denominated the "condensable"[2] composite resin. The 3M company has recently released an evolution of the Z-100 resin, the Filtek P-60 resin; however, these resins still require a sensitive technique and a long clinical time span that is quite problematic when treating children.

Also aiming at this segment of the market, Vivadent developed the Ariston pHc resin[10,12,14]. It is a resin that, according to the manufacturer, proportionally releases ions of calcium[17], fluoride and hydroxyl[11], when the pH of the oral cavity reaches values close to the critical limit. It inhibits or reduces the incidence of secondary caries[8,15,25] and the formation of plaque, remineralizing the dental structure through the deposition of calcium and fluoride, and neutralizing the effect of acids with hydroxyl ions[11,16,22].

The aim of this study was: to assess, *in vitro*, marginal microleakage in class II restorations restored with a glass ionomer cement and with two composite resins, to test the usefulness of thermocycling these materials and, also, to analyze two methods utilized in the evaluation of marginal microleakage.

MATERIAL AND METHODS

One hundred and twenty proximal surfaces of sixty healthy human premolars were selected and randomly split into three groups containing 20 premolars each (40 cavities). The teeth from Group I were restored with the resin-modified glass ionomer cement Vitremer; the teeth from Group II, with the "semi-condensable" resin Ariston pHc and those from Group III received the "condensable" resin P-60. All materials were handled following the manufacturers' instructions.

The proximal cavities of the modified class II type (vertical slots) were standardized: their buccolingual width was 4 mm, their depth, 1 mm at the gingival wall, and the gingival margin was located 1 mm beyond the cementoenamel junction. The specimens were immersed in deionized water at 37°C for 24 hours and the groups were subdivided. Half of the restorations were kept in deionized water at 37°C and the other half was submitted to thermocycling – distilled water baths of 15 seconds, at 5°C (± 2) and 55°C (± 2), totalizing 500 cycles. Thereafter, all teeth received two layers of nail polish, respecting a margin of 1 mm around the restorations. They were submerged in an aqueous basic 0.5% fuchsin solution for 24 hours at 37°C and, finally, thoroughly rinsed in running water for 24 hours.

For the analysis of microleakage, the teeth were sectioned in a mesio-distal direction, which produced 4 to 5 sections per specimen, with the thickness of 0.8 to 1.0 mm. Each identified section was then scanned. Two images were obtained for each segment, which resulted in 8 surfaces for the analysis.

Dye penetration through the interface was measured with the Imagetools software. All sections obtained from the same tooth were analyzed, taking in account, for purposes of comparison between the groups, the average values of infiltration and the higher value of dye penetration.

The data were analyzed through the 2-way ANOVA test and Tukey's multiple comparison test, with a significance level of 5%.

RESULTS

The results obtained with and without thermocycling can be seen in Table 1. They reveal the similarity between the behaviors of the materials, evaluated by means of the maximum infiltration values and by the average of the observed infiltration values.

First, the statistic test was carried out with the average infiltration values (Table 2), and the existence of a statistically significant difference at the level of 5% was verified.

TABLE 1 - Mean values ($\overline{X}$) and standard deviation (sd) of mean and maximum infiltration, obtained for the three tested materials, with and without thermocycling.

Studied material	Thermo-cycling	Average		Maximum	
		$\overline{X}$ (mm)	sd (mm)	$\overline{X}$ (mm)	sd (mm)
Vitremer	with	0.0455	0.0960	0.1120	0.2134
	without	0.0280	0.0504	0.1145	0.1729
Ariston pHc	with	0.6440	0.3423	0.9330	0.4024
	without	0.7165	0.4291	1.0260	0.4507
P-60	with	0.5725	0.3369	0.8960	0.3408
	without	0.3715	0.3322	0.6215	0.3829

TABLE 2 - Parameters for the 2-way ANOVA employing the values of mean infiltration obtained for each specimen.

Variation source	df Effect	MS Effect	df Error	MS Error	F	p
Material	2*	4.3127*	114*	0.0895*	48.1846*	0.0000*
Thermocycling	1	0.0710	114	0.0895	0.7938	0.3748
Interaction	2	0.0194	114	0.0895	2.1707	0.1188

*Significant at the level of 5%.

TABLE 3 - Tukey's test applied to mean values for multiple comparisons between the materials.

Studied material	$\overline{X}$			
Vitremer	0.0367	▮		
P-60	0.0472		▮	
Ariston pHc	0.0680			▮

There is statistical difference between the groups that are not linked by a vertical bar.

The results from all groups were gathered in order to carry out the Tukey's test (Table 3).

However, when using the maximum microleakage value obtained for each specimen (Table 4), besides the statistical significant difference between the tested materials (at the level 5%), the results also revealed a significant interaction between the groups. Therefore, in order to apply the Tukey's test, the groups were divided according to the submittal to thermocycling (Table 5).

DISCUSSION

In this research, an average of 4 sections of each tooth, cut in a mesio-distal direction, was obtained, allowing for up to eight analysis per tooth and for up to 160 analysis for each sub-group.

Table 1 shows that Vitremer submitted to thermocycling, evaluated by means of the average infiltration values, presented an average value of 0.0455 mm, which was similar to the results obtained when it was not submitted to thermocycling (0.0280 mm). These values came even closer to each other when the samples were evaluated by means of their maximum infiltration, corresponding to 0.1120 mm and 0.1145 mm for Vitremer with and without thermocycling, respectively. The proximity to zero, which means improved efficacy in reducing microleakage, can be imputed to the adhesion of the material to the dental structure and to the similarity between its thermal expansion ratio and that of the dental structure – that was the material that presented the lowest microleakage values in this research. These data are in agreement with those obtained by several other authors[4,19,21,24] who considered that the results obtained with Vitremer were the best ones. On the other hand, these results differ from those obtained by VIEIRA *et al.*[27], who stated that there was no difference as to marginal microleakage when comparing Vitremer, Dyract and Compoglass, and from the results obtained by CARRARA[5], who considered the performances of Vitremer, Compoglass and Z-100 similar to each other, although the materials and methodologies utilized were different.

Table 1 also shows that the resin P-60 was the most affected by thermocycling. Regarding the average infiltration, P-60 presented values of

TABLE 4 - Parameters for the 2-way ANOVA using the maximum infiltration value found for each specimen.

Variation source	df Effect	MS Effect	df Error	MS Error	F	p
Material	2*	8.1052*	114*	0.1172*	69.1479*	0.0000*
Thermocycling	1	0.1068	114	0.1172	0.9112	0.3418
Interaction	2*	0.3666*	114*	0.1172*	3.1277*	0.0476*

*Significant at the level of 5%.

BIJELLA, M. F. B.; BIJELLA, M. F. T. B.; SILVA, S. M. B. da. *In vitro* quantitative evaluation of marginal microleakage in class II restorations confected with a glass ionomer cement and two composite resins. **Pesqui Odontol Bras**, v. 15, n. 4, p. 277-282, out./dez. 2001.

TABLE 5 - Tukey's test applied to the maximum values for multiple comparisons between materials.

Studied material	Thermo-cycling	$\overline{X}$			
Vitremer	with	0.1120	█		
	without	0.1145	█		
P-60	without	0.6215		█	
	with	0.8960		█	█
Ariston pHc	with	0.9330		█	█
	without	1.0260			█

There is no statistical difference between the groups linked by a vertical bar.

0.5725 mm and 0.3715 mm, with and without thermocycling, respectively; regarding maximum infiltration, the values were 0.8960 mm with thermocycling and 0.6215 mm without it, which points out the increase of microleakage when thermocycling was applied, although there was no statistically significant difference. These data corroborate the findings of ROSSOMANDO, WENDT JUNIOR[23] (1995), who observed that, for composite resins, there is no statistically significant difference related to the utilization of thermocycling.

The resin Ariston pHc, unlikely P-60 (Table 1) and maybe due to its specific properties, underwent an intermediate dislodgment in which thermocycling positively influenced its microleakage. It presented higher microleakage values than the other tested materials. When average microleakage measurements were considered, the values were 0.6440 mm and 0.7165 mm, with and without thermocycling, respectively. When maximum infiltration was taken into account, the values were 0.9330 mm and 1.0260 mm, with and without thermocycling, respectively. These results could be due to the fact that Ariston pHc presents a level of polymerization shrinkage similar to that of the new composite resins (2.2%) but it utilizes a single "liner" for dentinal sealing – that could cause marginal fissures. However, FONTANA *et al.*[8] (1999) and SCHIFFNER[25] (1999), in studies on the efficacy of this material against secondary caries, are unanimous in stating that Ariston pHc has demonstrated the best performance in cavities with marginal fissures, suggesting that the existence of these fissures enhances its protective effect by producing an unpropitious environment for the development of *S. mutans*, through the proclaimed exchanges of ions. These exchanges (release of Ca^{++}, F^{-} and OH^{-}) are also underscored by other authors[12,22]. KIELBASSA *et al.*[15] (1999), in a research carried out *in situ*, compared the release of fluorine by Ariston pHc, Dyract, Vitremer and Ketac-Molar. They concluded that only Ariston pHc presented a significant reduction of the prevalence of caries. The authors suggested that restoring materials that are addressed to prevent secondary caries should release both ions fluorine and hydroxyl.

Considering the microleakage mean values (Table 2), the results of the 2-way ANOVA demonstrated the existence of a statistically significant difference, at the level of 5%, between the studied materials. However, the results demonstrated that there is no significant interaction (p = 0.11) nor statistically significant difference related to the submittal to thermocycling (p = 0.37).

Based on these results, the Tukey's test for multiple comparisons was carried out considering all groups of the study, regardless of the submittal to thermocycling (Table 3).

The results revealed statistically significant difference between the "condensable" resin P-60 and the "semi-condensable" resin Ariston pHc, which is in disagreement with the conclusions of BRAUN *et al.*[1] (2000), who, in a six-month clinical survey, found out that there is no statistically significant difference between the marginal sealing of the "condensable" composite resin Solitaire and the "semi-condensable" composite resin Ariston pHc, although the methodologies of both studies were different.

Considering the maximum microleakage values (Table 4) the results of the 2-way ANOVA revealed that, besides the statistically significant difference (at the level of 5%) between the tested materials, there is also a significant interaction between the groups, showing that thermocycling influenced the tested materials in different ways, although without statistic significance. Thus, to carry out the Tukey's test (Table 5) the groups were divided, separating the specimens that had or had not been submitted to thermocycling. However, among the tested materials, Vitremer was regarded as the one that allowed for the smallest dye penetration, regardless of thermocycling. However, when considering the resins P-60 and Ariston pHc, an interaction is verified, especially when thermocycling had been carried out.

The results obtained in this research are in agreement with those obtained by DÉJOU *et al.*[7]

(1996), who stated that the maximum statistic infiltration parameter is the most suited comparative measure for clinical conditions, because even if it is small, when the significance level of 5% is applied, it is possible to see the interaction between materials.

The results of this research revealed that none of the studied materials was able to totally prevent marginal microleakage, although there was a statistically significant difference between them. Vitremer presented the smallest microleakage, followed by the composite resins P-60 and Ariston pHc, which were similar to each other. Regarding thermocycling, *in vitro* studies on microleakage demonstrated that, in spite of influencing the materials in different ways, the procedure did not lead to statistical differences. As to the methods for the evaluation of microleakage, maximum infiltration seems to have a greater clinical value since it detects more precisely the extension of microleakage.

Additionally, Ariston pHc, notwithstanding the presented results, may be of some importance in pedodontics because, even if it does not completely seal the tooth-restoration interface eliminating microleakage, it is said to have preventive properties[8,15,25] – release of Ca^{++}, F^- and OH^- – which, according to reports, prevent or delay the development of secondary caries, maintaining a satisfactory oral environment. Nonetheless, more laboratorial and clinical evidences that prove the effectiveness of this material are necessary.

CONCLUSIONS

Based on these results, it is possible to conclude that all tested groups presented marginal microleakage. Vitremer presented the best results, followed by P-60 and Ariston pHc. There was no statistically significant difference related to thermocycling and, regarding the methods for evaluating microleakage, the method that employs values of maximum infiltration seems to be the best in detecting the extent of microleakage.

BIJELLA, M. F. B.; BIJELLA, M. F. T. B.; SILVA, S. M. B. da. Avaliação quantitativa *in vitro* da microinfiltração marginal em restaurações classe II, confeccionadas com um cimento de ionômero de vidro e duas resinas compostas. **Pesqui Odontol Bras**, v. 15, n. 4, p. 277-282, out./dez. 2001.

Avaliou-se *in vitro* a microinfiltração marginal em restaurações classe II realizadas com Vitremer, com as resinas compostas Ariston pHc e P-60, com o propósito de verificar a influência da ciclagem térmica para estes materiais, como também dois métodos de análise da penetração do corante. Foram utilizados 60 pré-molares, divididos em 3 grupos, cujas cavidades proximais apresentavam parede cervical 1 mm abaixo da junção cemento-esmalte. Metade de cada grupo sofreu processo de termociclagem, enquanto a outra metade permaneceu em água deionizada a 37°C. Os espécimes foram imersos em solução de fucsina básica a 0,5% por 24 horas a 37°C. Para análise da microinfiltração, os dentes foram seccionados no sentido mésio-distal e a análise realizada através do software Imagetools. Os resultados foram avaliados através do teste ANOVA 2-critérios e Tukey. Pelos resultados, todos os grupos apresentaram microinfiltração marginal, sendo menores para o Vitremer, seguidos pela resina composta P-60 e por último pela resina Ariston pHc. Não houve diferença estatisticamente significante no uso ou não da termociclagem e o método através da máxima infiltração demonstrou ser o melhor para detectar a extensão da microinfiltração.

UNITERMOS: Infiltração dentária; Resinas compostas; Cimentos de ionômero de vidro.

BIBLIOGRAPHIC REFERENCES

1. BRAUN, A. R.; FRANKENBERGER, R.; HARDT, N. *et al.* Margin analysis of two different resin composite systems after six months. **J Dent Res**, v. 79, p. 186, 2000. [Abstract n. 339]
2. BUSATO, A. L. S.; RESTON, E. G.; GONZÁLEZ, P. A. H. *et al.* Restaurações diretas em resinas compostas para dentes posteriores: cursos antagônicos. *In*: FELLER, C.; GORAB, R. **Atualização na clínica odontológica**. São Paulo : Artes Médicas, 2000. v. 2, cap. 1, p. 3-27.
3. CARDOSO, M.; VIEIRA, L. C. C. Infiltração marginal em cavidades classe II MOD em pré-molares. **Rev Assoc Paul Cir Dent**, v. 52, n. 1, p. 65-68, jan./fev. 1998.
4. CARRARA, C. E. **Avaliação da infiltração marginal de dois cimentos de ionômero de vidro híbridos restauradores**. Bauru, 1995. 74 p. Dissertação (Mestrado) - Faculdade de Odontologia de Bauru, Universidade de São Paulo.
5. CARRARA, C. E. **Avaliação da infiltração marginal e resistência ao cisalhamento de materiais restauradores adesivos em dentes decíduos**. Bauru, 1999. 114 p. Tese (Doutorado) - Faculdade de Odontologia de Bauru, Universidade de São Paulo.
6. CARVALHO, R. M. Ionômero de vidro. **Maxi-Odonto: Dentística**, v. 5, n. 5, p. 1-42, set./out. 1995.
7. DÉJOU, J.; SINDRES, V.; CAMPS, J. Influence of criteria on the results of *in vitro* evaluation of microleakage. **Dent Mater**, v. 12, n. 6, p. 342-349, Nov. 1996.

8. FONTANA, M.; GONZÁLEZ-CABEZAS, C.; WILSON, M. E. *et al*. *In vitro* evaluation of a "smart" dental material for its efficacy in preventing secondary caries using a microbial artificial mouth model. **Am J Dent**, v. 12, p. S8-9, Nov. 1999. Special issue.
9. FUTATSUKI, M.; NAKATA, M. *In vitro* marginal leakage of class II composite resin restorations by thermal cycling. **J Clin Pediatr Dent**, v. 18, n. 3, p. 191-196, June 1994.
10. GARCÍA-GODOY, F. A new ion-releasing restorative material. **Am J Dent**, v. 12, p. S3, Nov. 1999. Special issue.
11. GOLCKMANN, E.; BECHMANN, H.; SIGUSCH, B. Fluoride, calcium and hydroxide release from the smart restorative material Ariston pHc. **J Dent Res**, v. 79, p. 184, 2000. [Abstract n. 328]
12. GOMES, J. C.; CAVINA, D. A.; GOMES, O. M. M. Uma nova opção de material restaurador estético para dentes posteriores. **Rev Gaúcha Odontol**, v. 48, n. 2, p. 71-74, abr./jun. 2000.
13. GWINNETT, J. A.; TAY, F. R.; PANG, K. M. *et al*. Comparison of three methods of critical evaluation of microleakage along restorative interfaces. **J Prosthet Dent**, v. 74, n. 6, p. 575-585, Dec. 1995.
14. HEINTZE, S. D. A new material concept for inhibiting the formation of secondary caries. **Am J Dent**, v. 12, p. S4-7, Nov. 1999. Special issue.
15. KIELBASSA, A. M.; MÜLLER, U.; GARCÍA-GODOY, F. *In situ* study on the caries-preventive effects of fluoride-releasing materials. **Am J Dent**, v. 12, p. S13-4, Nov. 1999. Special issue.
16. KIELBASSA, A. M.; MÜLLER, U.; WRBAS, K. T. *et al*. Influence of fluoride-releasing restorative materials on *in situ* induced demineralization. **J Dent Res**, v. 79, 2000. [Abstract n. 3743]
17. KRAMER, N.; DISTLER, W.; FRANKENBERGER, R. *et al*. Calcium release of a new "smart" resin composite. **J Dent Res**, v. 79, p. 162, 2000. [Abstract n. 152]
18. MARTIN, F. F.; BRYANT, R. W. Acid etching of enamel cavity walls. **Aust Dent J**, v. 29, n. 5, p. 308-314, Oct. 1984.
19. MILLER, M. B.; CASTELLANOS, I. R.; VARGAS, M. A. *et al*. Effect of restorative materials on microleakage of class II composites. **J Esthet Dent**, v. 8, n. 3, p. 107-113, May 1996.
20. NAVARRO, M. F. L.; PASCOTTO, R. C. Cimento de ionômero de vidro. *In:* ________. **Cimento de ionômero de vidro**. São Paulo : Artes Médicas, 1998. Cap. 1, p. 1-24.
21. PIN, M. L. G. **Avaliação da infiltração marginal em restaurações classe II modificadas, confeccionadas com um cimento de ionômero de vidro convencional, dois cimentos de ionômero de vidro modificado por resina e uma resina composta modificada por poliácidos**: estudo *in vitro*. Bauru, 1997. 124 p. Dissertação (Mestrado) - Faculdade de Odontologia de Bauru, Universidade de São Paulo.
22. PIRES, L. A. G.; PACHECO, J. F. M. Uma nova alternativa restauradora direta de cor branca para dentes posteriores. **Rev Assoc Paul Cir Dent**, v. 53, n. 6, p. 499-504, nov./dez. 1999.
23. ROSSOMANDO, K. J.; WENDT Jr., S. L. Thermocycling and dwell times in microleakage evaluation for bonded restorations. **Dent Mater**, v. 11, n. 1, p. 47-51, Jan. 1995.
24. SALLES, V. **Avaliação *in vitro* da influência de dois adesivos dentinários na infiltração marginal de restaurações realizadas com um cimento de ionômero de vidro modificado por resina e uma resina composta modificada por poliácidos**. Bauru, 1997. 108 p. Dissertação (Mestrado) - Faculdade de Odontologia de Bauru, Universidade de São Paulo.
25. SCHIFFNER, U. Inhibition of enamel and root dentin demineralization by Ariston pHc: an artificial mouth study. **Am J Dent**, v. 12, p. S10-2, Nov. 1999. Special issue.
26. SHIDU, S. K.; WATSON, T. F. Resin-modified glass ionomer materials – a status report for the American Journal of Dentistry. **Am J Dent**, v. 8, n. 1, p. 59-67, Feb. 1995.
27. VIEIRA, R. S.; ALMEIDA, I. C. S.; OLIVEIRA, J. *et al*. Avaliação da infiltração marginal em restaurações de ionômero de vidro modificado por resinas compostas e resina composta modificada por poliácidos. **Rev Bras Odontol**, v. 56, n. 3, p. 139-143, maio/jun. 1999.

Recebido para publicação em 28/11/00
Enviado para reformulação em 11/04/01
Aceito para publicação em 08/06/01