Braz Dent J (2001) 12(2): 85-89 ISSN 0103-6440

Radiopacity of Glass-Ionomer/Composite Resin Hybrid Materials

Anderson Takeo HARA[1]
Mônica Campos SERRA[1]
Antonio Luiz RODRIGUES Jr.[2]

[1]Department of Restorative Dentistry, School of Dentistry, Piracicaba, UNICAMP, Piracicaba, SP, Brazil
[2]Discipline of Bioestatistics and Scientific Methodology, School of Dentistry, Araraquara, UNESP, Araraquara, SP, Brazil

This study visually compared the radiopacity of seven restorative materials (3 resin-modified glass-ionomer cements, 3 polyacid-modified composite resins, and 1 conventional glass-ionomer cement) to a sound tooth structure sample, and an aluminium stepwedge. All hybrid materials were more radiopaque, except for one resin-modified glass-ionomer cement, than both the tooth structure and conventional glass-ionomer cement.

Key Words: radiopacity, glass-ionomer/composite resin hybrid materials, restorative materials.

INTRODUCTION

Glass-ionomer/composite resin hybrid materials have recently been introduced. These new materials may be called either resin-modified glass-ionomer cement, or polyacid-modified composite resin depending on whether or not an acid-base reaction occurs as part of the polymerization process, and whether that process occurs in the dark or in the presence of light (1).

The advantages of hybrid materials over conventional glass-ionomer cements are working time control, less sensitivity to moisture (2), higher fracture strength and fatigue resistance (3), lower solubility, and better esthetics (4). Characteristics such as fluoride release, and molecular bond-to-tooth structure seem to be, at least, the same as those of the conventional glass-ionomer cements (4). Other characteristics such as marginal microleakage (5), and biocompatibility (6) are currently being analyzed; however, there are few reports on the radiopacity of these new materials (7-9).

The relative radiopacity of restorative materials is an important auxiliary to diagnose secondary caries, detect excess restorative material on the cervical margins of proximal surfaces, determine the proximal contour of the restoration as well as its contacts with adjacent teeth (10,11), and, also, to distinguish restorative material from gaps or voids (12,13).

The purpose of this study was to visually evaluate the radiopacity of glass-ionomer/composite resin hybrid materials by comparing them to a conventional glass-ionomer cement and to sound tooth structure.

MATERIAL AND METHODS

This study evaluated restorative material at seven experimental levels compared to a control. The experimental units were 168 specimens, made of the materials analyzed in 8 stages or blocks. A 2-mm-thick standard experimental specimen made of a sound human tooth (1-mm-thick enamel and 1-mm-thick dentin) was used as control. In each block, 3 specimens of each of the 7 restorative materials were made in random sequence. At every stage, 3 radiographs were taken, each containing one specimen of each of the seven materials evaluated, plus the standard specimen of the tooth structure, randomly placed around the aluminium stepwedge. The restorative material radiopacity response was scored independently and by three examiners who were blind to the specimens.

Seven restorative materials were analyzed: 3

Correspondence: Profa. Dra. Mônica Campos Serra, Faculdade de Odontologia de Ribeirão Preto, Universidade de São Paulo, Av. do Café, s/n,14040-904 Ribeirão Preto, SP, Brasil. Tel: +55-16-602-4075. Fax: +55-16-633-0999. e-mail: mcserra@forp.usp.br

resin-modified glass-ionomer cements, 3 polyacid-modified composite resins, and 1 conventional glass-ionomer cement. Table 1 lists the materials used, their respective manufacturers, and their batch numbers.

The test was performed at 20 ± 1°C. Powder-liquid materials were prepared according to manufacturer instructions, using an electronic analytical balance with 0.0001 g accuracy (HR 200, A & D Co. Ltd., Tokyo, Japan). Capsulated materials that needed mechanical activation were mixed in a 4300-oscillation-per-minute mixer (Capmix, Espe GmbH & Co., Seefeld/Oberbay, Germany), according to the manufacturer instructions for time.

The materials were subsequently placed, with a syringe (Centrix, 3M Dental Products, St. Paul, MN), into the 2-mm deep and 4.1-mm internal diameter plastic rings, which had been previously fixed to a glass slab, and arranged into seven groups of three matrixes each, according to the block randomized sequence.

A mylar matrix strip (Odahcam, Herpo Produtos Dentários Ltd., Rio de Janeiro, RJ, Brazil) and a microscope glass slide (Knittel Gläser, Germany) were placed over the three plastic rings of each material and pressed with a 1000-g load, to allow for a smooth surface and no gap formation. The load was removed from the light-cured hybrid materials after 1 min, and they were light-cured for 40 s (XL 100; 3M Dental Products, St. Paul, MN). The load was removed from the conventional glass-ionomer cement after the initial set of 10 min. The specimen surface was protected according to manufacturer instructions.

After trimming the excess from all restorative materials with a number 11 surgical blade, each specimen was separately polished with fine and super fine flexible discs (Sof-lex, 3M Brazil, Sumaré, SP, Brazil); the surface was again protected.

In order to complete an experimental block the above procedures were performed for each of the 7 materials evaluated. The 8 experimental blocks were carried out at 1-week intervals.

After preparation, the specimens were stored under moist conditions at 37 ± 1°C until the radiographic part of the experiment was conducted. Radiographic exposures were taken one week after each of the experimental blocks had been made. The specimens were placed on periapical dental films (Ektaspeed, Eastman Kodak Co., Rochester, NY) of the same batch number. They also received a metal code letter and number according to the previously randomized order. One specimen of each of the 7 materials, as well as the tooth structure, and the ten-step aluminium stepwedge were placed on each film (Figure 1). The dental x-ray unit (Spectro 70X, Dabi Atlante, Ribeirão Preto, SP, Brazil) was set at 60 kVp, a current of 10 mA, and a standard exposure time of 0.4 seconds. Focus-film distance was kept constant at 10 cm. The films were processed in an automatic developing machine (A/T 2000 m, Air Techniques Inc., Hicksville, NY) at 5.5 min drying time.

Three examiners, independent and blinded, evaluated the 24 radiographs obtained using a standardized illumination source and a viewing box with 2X magnifying lenses, in a dark room. Scores from 1 to 5 (from the most radiolucent to the most radiopaque) were given to each of the 7 materials and the dental structure

Table 1. Materials, batch numbers and manufacturers.

Product	Material	Batch	Manufacturer
Compoglass	Polyacid-modified composite resin	717258	Vivadent EtsSchaan/Liechtenstein
Dyract	Polyacid-modified composite resin	950927	De Tray Division – Dentsply Weybridge, England
Fuji II LC	Resin-modified glass-ionomer cement	P:270751 L:250751	GC Corporation Tokyo, Japan
Ketac-Fil aplicap	Conventional chemically cured glass-ionomer cement	Z095	ESPE GmbH Seefeld, Germany
Photac-Fil aplicap	Resin-modified glass-ionomer cement	21032	ESPE GmbH Seefeld, Germany
Variglass	Polyacid-modified composite resin	27572	Dentsply Ind. e Com. Ltda. Petrópolis, RJ, Brazil
Vitremer	Resin-modified glass-ionomer cement	P:6106 L:650	3M Dental Products St. Paul, MN, USA

by comparing them to the aluminium stepwedge. The following criteria was used to score the degree of radiopacity of each specimen: 1 = radiopacity ranging from 1 to 2 mmAl (1st and 2nd step of aluminium stepwedge); 2 = radiopacity ranging from 3 to 4 mmAl; 3 = radiopacity ranging from 5 to 6 mmAl; 4 = radiopacity ranging from 7 to 8 mmAl; 5 = radiopacity ranging from 9 to 10 mmAl.

The non-parametric Kruskal-Wallis test was used to compare the materials studied, and the Multiple Comparison test was used to determine the paired differences (14). The median of scores of each restorative material was taken from 9 observations (3 examiners X 3 radiographs) in each block for statistical analysis.

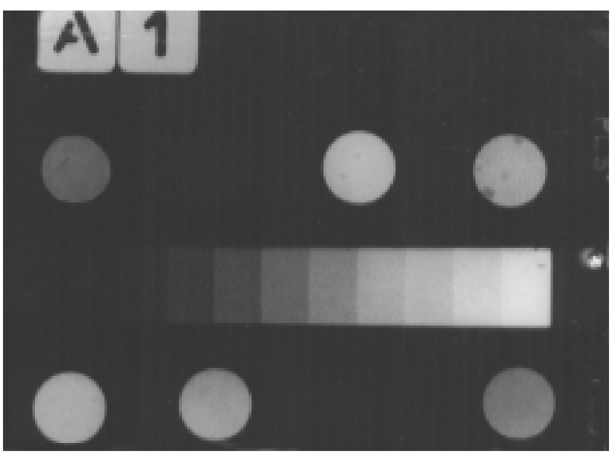

Figure 1. The specimens were randomly placed on the codified periapical dental film, around of the aluminium stepwedge. Specimens above the stepwedge (from left to right): tooth structure, Ketac-fil, Variglass, Fuji II LC; specimens below the stepwedge (from left to right): Compoglass, Dyract, Photac-fil, Vitremer.

Table 2. Exploratory values: measurements of position and variation of the radiopacity scores.

Material	Median	Higher	Lower	Amplitude
Variglass	5	5	5	0
Dyract	5	5	4	1
Compoglass	4	5	4	1
Fuji II LC	4	4	3	1
Vitremer	3	3	3	0
Tooth	2	2	2	0
Photac-Fil aplicap	1	1	1	0
Ketac-Fil aplicap	1	1	1	0

RESULTS

The Kruskal-Wallis test showed a highly significant difference among the materials (H = 58.36; $p<0.0001$). The Multiple Comparison test identified the differences by comparing them in pairs, by means of the least significant difference (lsd = 28.21; $\alpha = 0.05$). The results are presented in Tables 2 and 3.

As seen in Table 3, both Variglass and Dyract had the same degree of radiopacity, which was higher than that of the Compoglass. On the other hand, Compoglass was more radiopaque than Fuji II LC, and the latter was more radiopaque than Vitremer. All these materials were more radiopaque than tooth structure. Photac-fil and Ketac-fil were similar; however, they were more radiolucent than both the standard tooth structure, and the other restorative materials analyzed.

DISCUSSION

The relative radiopacity of restorative materials against tooth structure allows the diagnosis of secondary caries, the detection of voids, gaps, and excess restorative material in the cervical area. The evaluation of the proximal contours of the restoration and their contacts with adjacent teeth can also be evaluated with radiographs. Thus, it is recommended that restorative materials be radiopaque (10,11). However, radiopacity cannot be excessive, or it will obscure caries adjacent to a restoration (15). Hence, materials with a moderate degree of radiopacity are preferable to those with a high degree of radiopacity (16).

Table 3. Results of statistical analysis with the Kruskal-Wallis test and the Multiple Comparison test.

Material	Sum of the Ranks	Clusters
Variglass	452.0	A
Dyract	436.5	A
Compoglass	344.5	B
Fuji II LC	316.0	C
Vitremer	232.0	D
Tooth	164.0	E
Photac-Fil aplicap	68.0	F
Ketac-Fil aplicap	68.0	F

lsd = 28.21; $\alpha = 0.05$
Values followed by different letters are significantly different from each other.

The relative radiopacity of the materials evaluated in this study can be better ranked on a continuum between purely salt-matrix conventional glass-ionomer, and purely resin-matrix composite resin, as suggested by Gladys et al. (3). The polyacid-modified composite resins such as Variglass, Dyract, and Compoglass showed the highest radiopacity. The resin-modified glass-ionomer cements such as Fuji II LC, Vitremer, and Photac-fil were less radiopaque than the glass-ionomer composites, but, Photac-fil was as radiolucent as the Ketac-fil, which is a conventional glass-ionomer cement (Figure 2).

Differences in composition influence restorative material radiopacity (12,17). The relative radiolucency of Ketac-fil may be explained by the fact that it is a conventional glass-ionomer cement basically composed of a calcium fluoro-alumino-silicate glass powder, an aqueous solution containing the copolymer of polyacrylic acid-itaconic acid, and also tartaric acid (17,18). These elements do not provide for a relative radiopacity. The addition of elements such strontium, barium, and lanthanum, the fusing of silver to the glass, or even the mixing of zinc oxide, or zirconium oxide to glass-ionomer materials can make them radiopaque (17). The presence or absence of these elements seems to be responsible either for the radiopacity or the radiolucency of the restorative materials studied.

Glass-ionomer/composite resin hybrid materials were developed by adding resin to conventional glass-ionomer cement (19) in an attempt to compensate for its inadequacies such as the relative radiolucency, and to maintain its positive characteristics such as fluoride release and molecular bond-to-tooth structure (4). Variglass, Dyract, Compoglass, Fuji II LC, and Vitremer were found to have satisfactory radiopacity because they were more radiopaque than enamel and dentin. Only Photac-fil was not more radiopaque than enamel and dentin. The results obtained by the resin-modified glass-ionomers Fuji II LC, Vitremer, and Photac-fil are in agreement with a recent study that analyzed the radiopacity of the same materials (7).

The periapical radiographic exposures at a focus-film distance of 10 cm, as well as the evaluation by three examiners, were chosen in an attempt to mimic the clinical situation. The standardization of 2-mm-thick specimens was based on the depth of carious lesions, considering that, clinically, the presence of dentin lesion is the minimum required situation for the indication of restorative procedures (20).

Thus, it can be concluded that all materials, with the exception of one resin-modified glass-ionomer cement, were more radiopaque than the conventional glass-ionomer cement and the tooth structure.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to the following at the School of Dentistry, University of Campinas, Piracicaba, São Paulo: Professors Doctors Francisco Haiter-Neto, and Frab Boscolo, Department of Radiology, for the use of their facilities; Ana Paula Ribeiro, Cláudia Silami Magalhães, and José Augusto Rodrigues, our colleagues at the Department of Restorative Dentistry, for their participation in this study as examiners. We would like to acknowledge FAPESP for the scholarship (Process nº 96/6044-2). The authors are grateful to MA Themis Euterpe Storino for translating this paper.

RESUMO

Hara AT, Serra MC, Rodrigues Jr AL. Radiopacidade de materiais híbridos de ionômero de vidro/resina composta. Braz Dent J 2001;12(2):85-89.

Este estudo comparou, visualmente, a radiopacidade de sete materiais restauradores - três ionômeros de vidro modificados

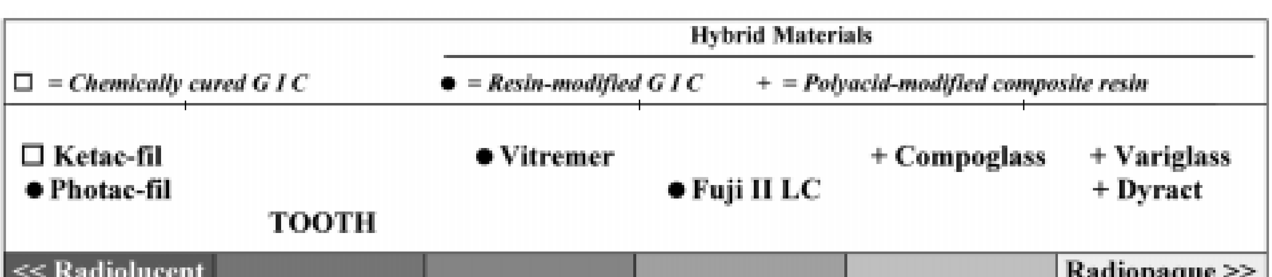

Figure 2. Continuum of materials regarding radiopacity.

por resina, três resinas compostas modificadas por poliácidos, e um cimento de ionômero de vidro convencional - com uma amostra de estrutura dental hígida, e uma escala de alumínio. Os resultados demonstraram que, exceto um ionômero de vidro modificado por resina, todos os materiais híbridos avaliados foram mais radiopacos que a amostra de estrutura dental e que o cimento de ionômero de vidro convencional.

Unitermos: radiopacidade híbridos de ionômero de vidro/resina composta, material restaurador.

REFERENCES

1. McLean JW, Nicholson JW, Wilson AD. Proposed nomenclature for glass-ionomer dental cements and related materials. Quint Int 1994;25:587-589.
2. Nicholson JW, McLean JW. A preliminary report on the effect of storage in water on the properties of commercial light-cured glass-ionomer cements. Br Dent J 1992;173:98-101.
3. Gladys S, van Meerbeek B, Braem M, Lambrechts P, Vanherle G. Comparative physico-mechanical characterization of new hybrid restorative materials with conventional glass-ionomer and resin composite restorative materials. J Dent Res 1997;76:883-894.
4. Christensen GJ. Glass-ionomer resin: a maturing concept. J Am Dent Assoc 1993;124:248-249.
5. Crim GA. Marginal leakage of visible light-cured glass-ionomer restorative materials. J Prosthet Dent 1993;69:561-563.
6. Woolford MJ, Chadwick RG. Surface pH of resin-modified glass polyalkenoate (ionomer) cements. J Dent 1992;20:359-364.
7. Sidhu SK, Shah PMM, Chong BS, Pitt Ford TR. Radiopacity of resin-modified glass-ionomer restorative cements. Quint Int 1996;27:639-643.
8. Shah PMM, Sidhu SK, Chong BS, Pitt Ford TR. Radiopacity of resin-modified glass-ionomer liners and bases. J Prosthet Dent 1997;77:239-242.
9. Marouf N, Sidhu SK. A study on the radiopacity of different shades of resin-modified glass-ionomer restorative materials. Oper Dent 1998;23:10-14.
10. Council on Dental Materials, Instruments, and Equipment. The desirability of using radiopaque plastics in dentistry: a status report. J Am Dent Assoc 1981;102:347-349.
11. Akerboom HBM, Kreltlen CM, van Amerongen WE, Mol A. Radiopacity of posterior composite resins, composite resin luting cements, and glass-ionomer lining cements. J Prosthet Dent 1993;70:351-355.
12. de Abreu MJ, Tavares D, Vieira DF. Radiopacity of restorative materials. Oper Dent 1977;2:3-16.
13. Tamburus JR. Radiopacidade de resinas compostas. Rev Odont USP 1990;4:103-107.
14. Campos H. Estatística experimental não paramétrica. 3rd ed. Piracicaba: Editora Esalq, 1993.
15. Tveit AB, Espelid I. Radiographic diagnosis of caries and marginal defects in connection with radiopaque composite fillings. Dent Mat 1986;2:159-162.
16. Espelid I, Tveit AB, Erickson RL, Keck SC, Glasspoole EA. Radiopacity of restorations and detection of secondary caries. Dent Mat 1991;7:114-117.
17. Smith DC. Composition and characteristics of glass-ionomer cements J Am Dent Assoc 1990;120:20-22.
18. Wilson AD. Resin-modified glass-ionomer cements. Int J Prosthod 1990;3:425-429.
19. Christensen GJ. Restoration of pediatric posterior teeth. J Am Dent Assoc 1996;127:106-108.
20. Dirks OB. Post eruptive changes in dental enamel. J Dent Res 1966;45:503-511.

Accepted December 9, 2000