Radiopacities of Glass Ionomer Cements Measured With Direct Digital Radiographic System

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ABSTRACT

Purpose: The purpose of this study was to determine and compare the radiopacities of 5 glass ionomer cements (GICs) of different thickness using a digital radiographic system—storage phosphor plate.
Methods: The GICs tested were Vitremer, Vitrofil LC, Magic Glass, Vitromolar, and Maxxion, distributed into the orifices of 16 acrylic plates made to a thickness of 2 mm, 3 mm, 5 mm, and 6 mm. Each plate was radiographed 3 times, and the images obtained were processed by computer. The images were read 3 times using the VixWin 2000 program, totaling 720 readings of radiographic density. One-way analysis of variance was applied for statistical analysis with identification of differences using Scheffe's multiple comparisons test (α=5%).
Results: All the GICs varied in radiopacity according to thickness. Maxxion showed the lowest value of radiopacity, whereas Magic Glass displayed the highest level of radiopacity at all thicknesses studied. However, Vitremer and Vitrofil LC showed similar results.
Conclusion: It is important to know GIC radiopacities to help differentiate them from tooth structure and carious lesions as well as to use them correctly.
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The decision to engage in restorative treatment in areas where caries is suspected or to replace a defective restoration should be the result of detailed clinical and radiographic examinations.[1] In order to obtain a correct radiographic diagnosis, it is necessary to distinguish the restorative and liner materials from the tooth structure (enamel and dentin), as well as to differentiate these materials from previous or secondary caries.[2] Thus, knowing the radiopacity of materials is an indispensable prerequisite to their correct use and to monitor their long-term stability.[2]

Glass ionomer cements (**GICs**) have been widely utilized in pediatric dentistry[3,4] and general dentistry since their development in 1972.[5] Indications for their use have increased in the last decade because of their biocompatibility with the oral environment,[6,7] adhesion to tooth structures,[6-8] a coefficient of thermal expansion similar to that of teeth,[8] and improvements made in their properties.[7] GICs have made possible the development of less invasive techniques extensively used in contemporary pediatric dental care (eg, interim

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therapeutic restorations).[7,9] GIC properties such as fluoride release and recharge ability,[6,8-10] cariostatic potential,[6-8] and antimicrobial activity[6,11] contribute to its success as a liner, restorative material, sealant, and cement for bands or crowns.[3,9]

An alternative to conventional radiologic examinations is the utilization of digital systems. Despite having a high initial cost, these systems provide clinical and diagnostic advantages such as less exposure to radiation, rapid image processing, reduced toxic wastes from liquid processors, and the ability to utilize the systems' programs to handle images and make measurements, including the density of dental materials.[2,12]

The purpose of this study was to evaluate the radiopacity of GICs using digital radiography.

METHODS

Five restorative GICs were studied: 2 resin-modified products—Vitremer Pediatrico (3M/ESPE, St. Paul, Minn., USA) and Vitrofill A3 (DFL, Rio de Janeiro, Brazil); and 3 conventional ones—Vitromolar A3 (DFL), Maxxion R A3 (FGM, Joinville, Brazil), and Magic Glass R Kids (VigoDent, Rio de Janeiro, Brazil).

Sixteen transparent acrylic plates were made, 4 each with thicknesses of 2 mm, 3 mm, 5 mm, and 6 mm. All plates corresponded to approximately the dimensions of an occlusal radiographic film (5.7 x 7.6 cm), and thickness was measured with a Starret digital pachymeter series no. 727 with a precision of 0.01 mm (Starret Industry LTDA, Itu, Brazil). The upper left corner of each plate was marked for identification with numbers made with a no. 8 round bur. Vertical grooves were made beside the numbers in order to differentiate plates of the same thickness. The numbers and grooves were filled with an opaque composite resin, Glacier OA2 (SDI, Bayswater, Victoria, Australia), to make it possible to identify each plate in the radiographs.

Niches of 5 mm diameter were made with a no. 8 round bur in each acrylic plate, at 1, 3, 5, 7 and 9 o'clock positions. The thickness of the niches varied according to the thickness of the plates. The 16 acrylic plates were positioned separately on transparent glass plates of 5 mm thickness and lined with a plastic transparency sheet (Maxprint®, São Paulo, Brazil).

The materials were handled according to the manufacturers' instructions and inserted in the niches in the following order for all plates: Vitremer at 1 o'clock position; VitroFil LC at 3 o'clock; Magic Glass R Kids at 5 o'clock; Maxxion R at 7 o'clock; and Vitromolar at 9 o'clock. The photopolymerizable materials were placed in increments of a maximum of 2 mm thickness and polymerized for 40 seconds with the photopolymerizing apparatus XL 3000 (3M-ESPE, Seefeld, Germany) set at 550 mW/cm². The intensity was measured by a digital radiometer (Blue, DMC, Sao Carlos, Brazil).

The insertion of the material was done with a Centrix syringe (DFL, Rio de Janeiro, Brazil), and pressed with a smooth glass plate, with a plastic transparency sheet (Maxprint®) in between, in order to level the surfaces. After the polymerization of the samples, the plates were protected by a polyvinyl carbonate film to prevent contamination.

The samples were radiographed utilizing a 5.7 x 7.6 cm phosphor-activated plate of the digital system DenOptix (Gendex, Kavo, Milan, Italy) wrapped in plastic packaging. The X-ray apparatus was Timex-70X DRS (Gnatus, Ribeirão Preto, Brazil), with electrical specifications of 70 kVp and 7 mA and an aluminum filter of 2.5 mm. Standardization of the exposures was obtained by making the central X-ray beam perpendicular to the plate and with a focal distance of 40 cm. The exposure time was 0.64 seconds.

The 16 samples were radiographed 3 times, resulting in 48 images with a resolution of 300 dpi. After obtaining the image, the phosphor plate was exposed for 5 minutes to a strong-intensity light source (Negatoscope, Gnatus, Ribeirão Preto, Brazil) so that it could be radiographed again. The images were analyzed using the program VixWin 2000 from DenOptix. Three optical readings were made of each image, totaling 144 readings. Five materials were studied, resulting in 720 total radiopacity readings. Thirty-six readings were made at each thickness. For statistical procedures, a mean of the 3 readings was taken for the value of the radiopacity for each image. Optical density was determined using the tools available in the digital system DenOptix (grayscale, with graph of 0-256).

Statistical analysis was performed using 1-way analysis of variance, with a 5% level of significance and Scheffe's multiple comparison test, with a confidence level of 95%. The software used was Minitab v.15 (Minitab Inc, State College, Pa., USA).

ENERGY DISPERSION SPECTROSCOPY (EDS)

EDS is used to determine and quantify inorganic chemicals on the surface of a material. For this analysis, samples of 3 mm in diameter with 2 mm thickness were made utilizing matrix of teflon. The materials were handled according to the manufacturers' instructions and inserted in the matrix in a single increment with the aid of a Centrix syringe. After polymerization, they were kept for 48 hours in a low-vacuum dessicator to remove the humidity. After that, they were metallized with gold-palladium alloy and examined by scanning electron microscopy (XL30, Philips, Mahwah, NJ, USA). In the visual field at 1,000X magnification, the central area was selected and measured by EDS.

RESULTS

In this study, increased GIC thickness led to increased radiopacity (Tables 1–4). Maxxion showed the lowest radiographic density at all thicknesses examined while Magic Glass had the highest density at all thicknesses. Vitrofil LC and Vitremer did not statistically differ at thicknesses of 2 mm and 3 mm (Tables 1 and 2), whereas Vitrofil LC had a slightly higher radiopacity at thicknesses of 5 mm and 6 mm (Table 3 and 4). There were also qualitative differences in density between the GICs, which were related to their chemical composition. The quantity of opacifying elements varied widely among the commercial brands, with silicon appearing to be the most common one (Figure 1). Magic Glass had the greatest amount of silicon and Vitromolar the lowest. Both Vitromolar and Vitrofil LC showed barium in its composition in addition to silicon.

Table 1. Grayscale Level of Radiopacity: 2 mm–thick Glass Ionomer Cements (GICs)

GIC	Mean±SD*
Maxxion	76.89±3.06a
Vitromolar	136.24±2.57b
Vitremer	157.40±3.03c
Vitrofil LC	158.66±2.08c
Magic Glass	171.15±1.62d

*** Means followed by the same letter are not statistically significant (P<0.05).***

Table 2. Grayscale Level of Radiopacity: 3 mm–thick Glass Ionomer Cements (GICs)

GIC	Mean±SD*
Maxxion	89.55±1.97a
Vitromolar	153.03±4.05b
Vitremer	176.68±4.67c
Vitrofil LC	178.26±2.98c
Magic Glass	193.23±1.97d

*** Means followed by the same letter are not statistically significant (P<0.05).***

Table 3. Grayscale Level of Radiopacity: 5 mm–thick Glass Ionomer Cements (GICs)

GIC	Mean±SD*
Maxxion	111.63±4.22a
Vitromolar	180.65±2.03b
Vitremer	195.51±0.66c
Vitrofil LC	200.47±1.10d
Magic Glass	209.68±2.71e

*** Means followed by the same letter are not statistically significant (P<0.05).***

Table 4. Grayscale Level of Radiopacity: 6 mm–thick Glass Ionomer Cements (GICs)

GIC	Mean±SD*
Maxxion	119.83±2.83a
Vitromolar	189.05±1.43b
Vitremer	202.13±1.03c
Vitrofil LC	207.21±1.29d
Magic Glass	214.45±1.14e

*** Means followed by the same letter are not statistically significant (P<0.05).***

DISCUSSION

Many studies have been conducted to determine the radiopacity of ionomeric materials using different measurement techniques.[13-17] Although there are international standards that specify that all intraoral materials must have a radiopacity greater than 1 mm of aluminum, there is no consensus regarding ideal radiodensity.[15] This study found a statistically significant difference in radiopacity among the materials, likely due to differences in their thickness and chemical composition. The results showed that the greater the material thickness was, the more radiopaque it became. The 2 resin cements displayed similar results, but the conventional GICs differed significantly (Tables 1-4). The cements were analyzed by EDS to determine the possible opacifying elements used in their composition. Silicon was the principal element related to the opacity of the material (Figure 1). Magic Glass, which showed the highest radiopacity at all thicknesses, also showed the highest percentage of silicon (34, 92%). Maxxion, the least radiopaque GIC, did not have the lowest quantity of silicon, but this could be attributed to the presence of barium in Vitrofil LC and Vitromolar, which apparently diminished their radiopacity. The chemical composition of the materials is the greatest factor for the variations in density, but the proportion of powder and liquid can also alter these values; therefore, it is important to follow the manufacturer recommendations at the time of their handling.[16]

Manufacturers should also publish radiopacity values to allow the dental professional to determine where and when a certain product should be used for better results. For example, GICs of low radiographic density should

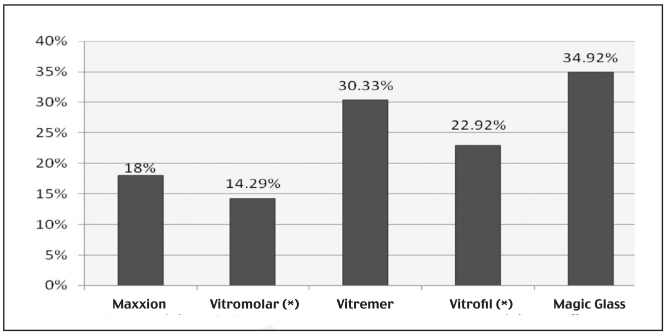

Figure 1. Distribution of particles of silicon oxide on the surface of glass ionomer cements.

*** Also contains barium.***

not be used in posterior teeth or as liners because otherwise they can be confused with caries.[17] The first choice in that situation should always be more radiopaque GICs.

Radiopacity can be measured with conventional films using densitometry or by digitization of the radiographs. The direct digital radiographic systems can utilize the sensors of the charge-coupled device (**CCD**) image type, introduced by Mouyen et al.,[18] or the systems that use phosphor-activated films, introduced by Wenzel and Gröndhal.[19] The technology has evolved rapidly, as did studies and comparisons of systems; the advantages or disadvantages of their utilization by professionals in dentistry continue to be scrutinized.[13,20,21]

The development and selection of suitable materials will surely be of benefit to patients as well as professionals. Dentists' familiarization with new technologies such as the Direct Digital Radiographic System is important, so that they can be also used for the radiographic identification of different kinds of dental materials.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. All GICs showed radiopacity variation directly proportional to their thickness.
2. The lowest radiopacity for all thicknesses was demonstrated by Maxxion, while the greatest was detected in Magic Glass.
3. Magic Glass was significantly more radiopaque in all analyzed thicknesses.

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