Radiopacity evaluation of root canal sealers containing calcium hydroxide and MTA

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Abstract: The purpose of this study was to evaluate the radiopacity of root canal sealers containing calcium hydroxide and MTA (Acroseal, Sealer 26, Sealapex, Endo CPM Sealer, Epiphany and Intrafill). Five disc-shaped specimens (10 x 1 mm) were fabricated from each material, according to the ISO 6876/2001 standard. After setting of the materials, radiographs were taken using occlusal film and a graduated aluminum stepwedge varying from 2 to 16 mm in thickness. The dental X-ray unit (GE1000) was set at 50 kVp, 10 mA, 18 pulses/s and distance of 33.5 cm. The radiographs were digitized and the radiopacity compared to that of the aluminum stepwedge using VIXWIN-2000 software (Gendex). The data (mmAl) were analyzed statistically by ANOVA and Tukey's test at the 5% significance level. Epiphany and Intrafill presented the highest radiopacity values (8.3 mmAl and 7.5 mmAl respectively, $p < 0.05$) followed by Sealer 26 (6.3 mmAl), Sealapex (6.1 mmAl) and Endo CPM Sealer (6 mmAl). Acroseal was the least radiopaque material (4 mmAl, $p < 0.05$). In conclusion, the calcium hydroxide- and MTA-containing root canal sealers had different radiopacities. However, all materials presented radiopacity values above the minimum recommended by the ISO standard.

Descriptors: Radiology; Radiography; Root canal obturation.

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Received for publication on Feb 03, 2008
Accepted for publication on Jun 30, 2008

Introduction

Root canal filling materials should present sufficient radiopacity to be distinguished from the adjacent anatomical structures.[1-4] Eliasson, Haasken[5] (1979) established a comparison standard for radiopacity studies in which the optical radiographic densities of several impression materials were measured and the values expressed as an equivalent thickness of aluminum capable of producing similar radiographic density.

Beyer-Olsen, Orstavik[1] (1981) included in their studies a reproducible comparison standard using a 2-mm-increment aluminum stepwedge to determine the radiopacity of several root canal sealers. Tanomaru-Filho *et al.*[6] (2007) evaluated the radiopacity of five root canal sealers (AH Plus, Intrafill, Roeko Seal, Epiphany and EndoRez) using a graduated aluminum stepwedge varying from 2 to 16 mm in thickness. AH Plus and Epiphany were the most radiopaque materials, followed by EndoRez, Roeko Seal and Intrafill.

In the search for materials with adequate biocompatibility, the addition of calcium hydroxide to the formulation of root canal sealers has been investigated.[7,8] However, the presence of calcium hydroxide tends to decrease the radiopacity of these materials.[9]

Sealapex (SybronEndo, Orange, CA, USA) was the first calcium hydroxide-based root canal sealer introduced to market with good biological properties.[8,10] Sealapex's manufacturer has recently modified its formulation by adding bismuth trioxide to improve its radiopacity properties and increase its shelf life.

Other calcium hydroxide-containing root canal sealers have been developed, such as Sealer 26 and, more recently, Acroseal. These sealers present epoxy resin in their composition, being derived from AH 26 sealer.

The recently launched Epiphany sealer is part of the Epiphany/Resilon system. It has a resinous characteristic and its formulation is based on methacrylates in addition to calcium hydroxide.[11] This material has been shown to have a good biological behavior.[12]

Mineral trioxide aggregate (MTA) has been widely indicated for several applications in Endodontics, among which sealing of perforations, pulp capping, pulpotomy, apexification and use as a retrofilling material. It is basically composed of Portland cement,[13] whose main components are tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium aluminoferrate and hydrated calcium sulfate. MTA also presents bismuth oxide, which is responsible for its radiopacity. According to Holland *et al.*[14,15] (1999, 2001), MTA and calcium hydroxide share the same mechanism of action. A new MTA-based root canal sealer has been recently launched under the brand name Endo CPM Sealer. Its basic composition is the same as that of MTA, the only difference being the addition of barium sulfate and calcium chloride.[16]

The purpose of this study was to compare the radiopacity of root canal sealers containing calcium hydroxide (Acroseal, Sealer 26, Sealapex, Epiphany) or MTA (Endo CPM Sealer) and a traditional zinc oxide and eugenol-based root canal sealer (Intrafill), according to the ISO 6876/2001 standard (2001), which recommends that root canal filling materials should be at least as radiopaque as 3 mm of aluminum thickness.

Material and Methods

Six root canal sealers were evaluated in this study: Acroseal, Sealer 26, Sealapex, Endo CPM Sealer, Epiphany and Intrafill (Table 1).

All materials were prepared according to the manufacturers' instructions. For specimen preparation, impressions were taken from metallic matrices using a light-bodied silicone-based impression material. The moulds were filled with the tested materials and stored in a moist chamber (incubator) at 37°C until complete set of the cements. Five specimens measuring 10 mm in diameter and 1 mm in thickness were fabricated from each material.

Thereafter, the specimens were placed onto 5 occlusal radiographic films (Insight; Kodak Comp., Rochester, NY, USA) next to a graduated aluminum stepwedge with thickness ranging from 2 to 16 mm (in 2 mm-increments) and exposed using a GE-1000 X-ray unit (General Electric, Milwaukee, WI, USA) operating at 50 kVp, 10 mA, 18 pulses/second, and

Table 1 - Tested materials, composition and manufacturers.

Material	Composition	Manufacturer
Acroseal	**Base Paste:** 2 g glycyrrhetic acid, 25 g methenamine, radiopaque excipient q.s.p. 100 g **Catalyst Paste:** 28 g calcium hydroxide, 17 g bisphenol A diglycidyl ether, radiopaque excipient q.s.p. 100 g	Septodont, Sant-Maur-des Fossés, Cedex, France
Sealer 26	**Powder:** bismuth trioxide, calcium hydroxide, hexamethylenetetramine and titanium dioxide **Paste:** bisphenol epoxy resin	Denstply Indústria e Comércio Ltda., Petrópolis, RJ, Brazil
Sealapex	20% calcium oxide, 2.5% zinc oxide, 29% bismuth trioxide, 3% silicon particles, 20% titanium dioxide, 1% zinc stearate, 3% tricalcium phosphate, isobutyl salicylate + methyl salicylate + 39% pigment	SybronEndo – Sybron Dental Specialties, Glendona, CA, USA
Endo CPM Sealer	**MTA:** silicon dioxide, calcium carbonate, bismuth trioxide, barium sulfate, propyleneglycol alginate, sodium citrate, calcium chloride, active ingredients	EGEO S.R.L. Bajo Licencia MTM Argentina S.A., Buenos Aires, Argentina
Epiphany	UDMA, PEGDMA, EBPADMA, BISGMA and methacrylate resins; barium borosilicate glasses treated with silane; barium sulfate; silica; calcium hydroxide; bismuth oxychloride with amines; peroxides; photopolymerization initiator; stabilizers and pigments	Pentron Clinical Technologies, LLC., Wallingford, CT, USA
Intrafill	Zinc oxide, hydrogenated colophony, colophony, bismuth subcarbonate, barium sulfate, anhydrous disodium borate, eugenol	SSWhite, Rio de Janeiro, RJ, Brazil

focus-film distance of 33.5 cm. The radiographs were digitized using a desktop scanner (SnapScan 1236; Agfa, Deutschland) and the digitized images were imported into the VIXWIN 2000 software (Gendex, Deplanes, IL, USA). The equal-density tool was used to identify equal-density areas, allowing comparison among the different materials' densities and the radiopacity of the different thicknesses of the aluminum stepwedge. Using the computer mouse, the specimen area was delimited in each radiographic image in order to determine which thickness of the aluminum stepwedge was detected by the software as presenting the same radiographic density as the sample. The optical density values may range from 0 to 255, according to VIXWIN software. After determining the optical density value for each specimen, the following equation was applied to convert the values into mmAl:

$$\text{Al equivalent (mm)} = \text{Radiopacity of the specimen} \times \frac{\text{Al thickness of the aluminum stepwedge (mm)}}{\text{Radiopacity of the stepwedge}}$$

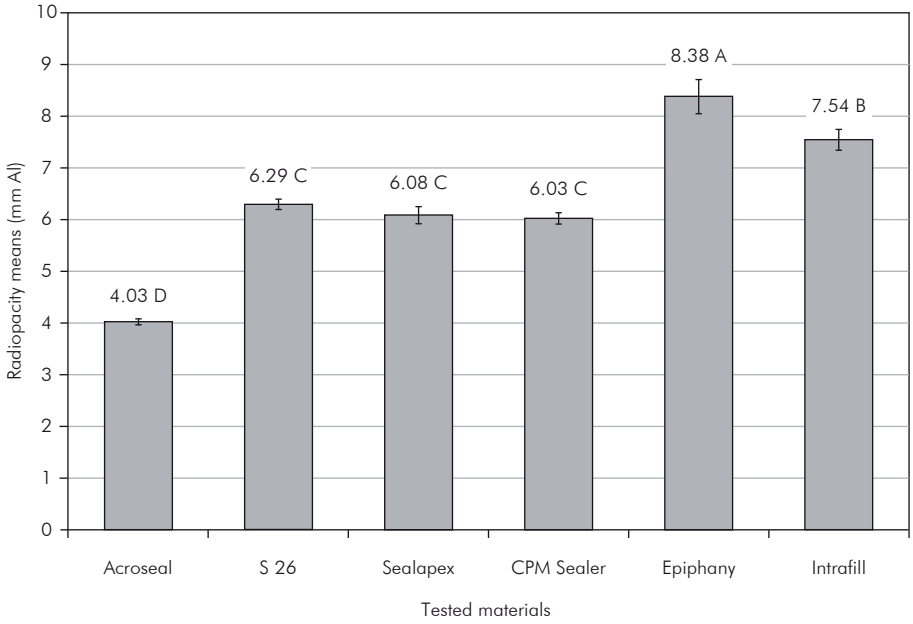
This equation determined the equivalence of each material's radiopacity to a particular thickness of the aluminum stepwedge, expressed in mm. The results were analyzed by calculating the arithmetic mean of five measurements per specimen. The data were submitted to statistical analysis by ANOVA and Tukey's test at the 5% significance level.

Results

The radiopacity values are presented in Graph 1. Epiphany and Intrafill had the highest radiopacity values among the tested materials ($p < 0.05$) (8.3 mmAl and 7.5 mmAl, respectively) followed by Sealer 26 (6.3 mmAl), Sealapex (6.1 mmAl) and Endo CPM Sealer (6 mmAl). Acroseal was the least radiopaque material (4 mmAl, $p < 0.05$).

Discussion

Tagger, Katz[17] (2003) developed a method for analysis of the radiopacity of endodontic sealers using standardized samples radiographed next to an aluminum stepwedge. In this method, the radiographs are digitized and the specimens' radiopacity is compared to that of the aluminum stepwedge using computer software. The comparative evaluation of digitized radiographic images using an image-analysis software has been shown to determine the



Graph 1 - Radiopacity means and standard deviation for the tested materials and results of the Tukey HSD *post-hoc* test ($\alpha = .05$). Same letters indicate that the groups were not significantly different ($p > .05$).

radiopacity of the materials in a simple and easily reproducible manner with reliable outcomes.[6,9,18]

Several radiopacity studies have included comparison to an aluminum stepwedge with varying thickness. Katz *et al.*[3] (1990) compared the radiopacity of gutta-percha cones to an aluminum stepwedge and observed a mean radiopacity of 7.4 mmAl. Tanomaru-Filho *et al.*[6] (2007) evaluated the radiopacity of root canal sealers using a similar methodology.

The ISO 6876/2001[19] standard establishes 3 mmAl as the minimum radiopacity for root canal sealers. According to the ANSI/ADA specification No. 57[20] (1984), root canal sealers should be at least 2 mmAl more radiopaque than bone or dentin. All sealers evaluated in the present investigation had radiopacity values above the minimum recommended by the ISO standard.

In this study, Epiphany and Intrafill and Sealer 26 presented greater radiopacity than the other sealers. Epiphany is essentially a polymer of polyester that contains silane-treated barium borosilicate glasses in addition to barium sulfate, bismuth and silica. According to the manufacturer, these substances confer radiopacity to the sealer. Intrafill contains zinc oxide, bismuth subcarbonate and barium sulfate, which contributes to its greater radiopacity. The results of Epiphany and Intrafill are consistent with those obtained by Carvalho-Júnior *et al.*[18] (2007) using a similar methodology.

Sealer 26 (6.3 mmAl), Sealapex (6.1 mmAl) and Endo CPM Sealer (6 mmAl) presented similar radiopacity. Sealer 26 contains bismuth trioxide, acting as the sealer radiopaque substance.[9]

The new formulation of Sealapex had greater radiopacity than the former formulation[9] due to the addition of bismuth trioxide to its composition. Bismuth trioxide replaced the barium sulfate present in the original formulation.

The MTA-based material, Endo CPM Sealer, had a satisfactory radiopacity value. Bismuth trioxide and barium sulfate are added to the material to provide radiopacity. Therefore, a material's radiopacity is compatible with its application as a root canal sealer.

Acroseal was less radiopaque than the other materials and its radiopacity is related to the presence of bismuth subcarbonate in its formulation. However, its radiopacity (4 mmAl) is in compliance with the specifications of the ISO standard.

Conclusions

The root canal sealers containing calcium hydroxide and MTA presented different radiopacities. However, all materials presented radiopacity values above the minimum recommended by the ISO standard.

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