Evaluation of the Radiopacity of New Root Canal Paste/Sealers by Digital Radiography

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Abstract

The aim of the present study was to assess the radiopacity of new polydimethylsiloxane-based root canal filling paste (GuttaFlow; Coltène/Whaledent, Langenau, Germany) and resin-based root canal sealer (Adseal; Meta Biomed Co, Cheongju, Korea) and compare their radiopacity with three currently used root canal sealers (AH Plus [Dentsply DeTrey GmbH, Konstanz, Germany], Epiphany [Pentron, Wallingford, CT], and Diaket [3M ESPE AG, Seefeld, Germany]) by means of direct digital radiography. Six specimens, 5 mm in diameter and 1 mm high, were performed for each material tested. After the material set, radiographs were made by using a digital sensor and a graduated aluminum stepwedge varying in thickness from 1 to 14 mm. These samples were tested according to the international standards to compare their radiodensity to that of the aluminum stepwedge. Data were analyzed using analysis of variance and Tukey tests. The millimeters of aluminum values reported in this study were 10.41, 8.20, 6.50, 4.90, and 3.09 for AH Plus, Epiphany, Diaket, GuttaFlow, and Adseal, respectively. Although the materials evaluated had different radiopacities, all of them showed radiopacity above the minimum recommended by the International Organization for Standardization and the American National Standards/American Dental Association. *(J Endod 2008;34:1388–1390)*

Key Words

Digital radiography, radiopacity, root canal paste/sealers

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An ideal root canal filling material should present, among other physical/chemical properties, sufficient radiopacity to allow for distinction from the surrounding anatomic structures (1, 2) such as bone and tooth (3). Additionally, radiopacity of root canal sealers has been of particular significance for the evaluation of the quality of endodontic treatment as well as being helpful in the assessment of possible voids in the obturation (4). Eliasson and Hasken (5) were the first to establish a standardized method of radiopacity measurements for dental materials. They measured the optical densities of the tested materials and calculated the equivalent thickness of aluminum necessary to produce a similar radiodensity. Beyer-Olsen and Ørstavik (1) included a reproducible comparison standard using an aluminum stepwedge to measure the radiopacity of 40 root canal sealing materials. Their results showed that different materials demonstrated wide variations in measurements, and most investigated materials were more radiopaque than dentin. According to the International Organization for Standardization (ISO) (6) and the American National Standards/American Dental Association (ANSI/ADA) (7), the root canal sealing materials should have a radiopacity of equivalent to not less than 3 mm of aluminum.

In recent years, new endodontic pastes and sealers have been proposed as innovative filling materials. The root canal filling paste GuttaFlow (Coltène/Whaledent, Langenau, Germany) includes the combination of gutta-percha in powder form and polydimethylsiloxane. Nanometer-sized particles of silver were added to gutta-percha powder, acting as a preservative. GuttaFlow is a modification of the RoekoSeal (RSA; Roeko, Langenau, Germany). Although positive results were obtained from the studies in which this material was used in sealing the canal (8–10), AH26 (Dentsply DeTrey GmbH, Konstanz, Germany) showed better sealing ability in root canals than GuttaFlow (11). It was reported that GuttaFlow was fairly stable and expanded slightly during hardening (12). This could be beneficial in preventing gap formation and decreasing microleakage because GuttaFlow does not show any chemical bonding to the canal wall. Also, ElAyouti et al. (13) reported that despite the presence of voids within the material, GuttaFlow showed good adaptability to root canal walls. More recently, Adseal (Meta Biomed Co, Korea) has been introduced into the market as a new material that is a resin-based root canal sealer. It is important to evaluate the physical and chemical properties, including radiopacity, of these new pastes/sealers.

The radiopacity of root canal sealers was established in a few studies using radiographic densitometry (1, 14). Other studies to date have investigated the radiodensity of root canal sealers by digitization of radiographic films (15–19) or using digital radiography (4, 20, 21). The ANSI/ADA standards for the radiodensity of root canal sealing materials have been determined using conventional dental films that the radiographic images must be obtained by the chemical processing of radiographic film, using developing and fixation solutions, rinsing, and drying (7). However, digital radiography is becoming increasingly more common. The advantages of digital radiography are numerous, including the advantages offered by many software packages for the quantitative analysis of radiographs, enabling improvements both in diagnosis and treatment decisions (4).

The objective of the present study was to evaluate the radiopacity of GuttaFlow and Adseal and compare their radiopacity with three currently used root canal sealers by means of direct digital radiography.

TABLE 1. Materials Used in This Study

AH Plus	Epoxy resins, zirconium oxide, iron oxide, calcium tungstate, silicone oil	Dentsply De Trey Gmbh, Konstanz, Germany
Epiphany	Bisphenol-A-glycidyldimethacrylate, polyethylene glycol dimethacrylate, ethoxylated bisphenol-A dimethacrylate, urethane dimethacrylate, barium sulphate, silica, calcium oxide, bismuth, pigments	Pentron, Wallingford, CT
Diaket	Powder: zinc oxide, propionyl, Liquid: acetophenone	3M ESPE AG, Seefeld, Germany
GuttaFlow	Gutta-percha powder, polydimethylsiloxane, silicone oil, paraffin oil, platinum catalyst, zirconium dioxide, nano-silver, coloring	Coltène/Whaledent, Langenau, Germany
Adseal	Epoxy oligomer resin, ethylene glycol salicylate, calcium phosphate, bismuth subcarbonate, zirconium oxide, poly aminobenzoate, triethanolamine, calcium oxide	Meta Biomed Co, Cheongju, Korea

Materials and Methods

Five root canal paste/sealers were evaluated in this study: GuttaFlow, Adseal, Epiphany (Pentron, Wallingford, CT), AH Plus (Dentsply DeTrey GmbH), and Diaket (3M ESPE AG, Seefeld, Germany) (Table 1). Six specimens were prepared from each material tested. Six plastic plates, containing 5 wells measuring 1 mm in depth and 5 mm in diameter, were produced. The materials were manipulated according to manufacturers' instructions and then introduced immediately into the wells. The specimens were stored in a moist chamber at 37°C until completely set.

Standardized radiographic images of the specimens were obtained by using a Kodak digital sensor (Eastman Kodak Co, Rochester, NY) alongside an aluminum stepwedge with variable thickness (from 1 to 14 mm, in 1-mm increments) that was used for reference. A Kodak 2100 intraoral x-ray unit was used, operating at 60 kV, 7 mA, and 0.20 second. The object-to-focus distance was 30 cm. The mean gray value of each aluminum stepwedge and selected materials were measured by outlining a region of interest by using the equal-density area tool of the Kodak dental imaging software 6.7 (Fig. 1). The regions were selected by avoiding areas containing air bubbles inside the material. This procedure was repeated five times for each specimen and aluminum stepwedge, and the average was calculated. The mean gray value of material was then converted to millimeters of aluminum equivalent, permitting the measurement of the studied materials. The measurement was undertaken by one evaluator, and the evaluator was blinded to the identity of the materials. Data were analyzed by using analysis of variance and Tukey tests.

Results

The measured mean radiopacity of each material and the results of Tukey tests ($\alpha = 0.05$) are presented in Figure 2. The values ranged from 3.09 to 10.41 mm of aluminum per millimeter of material. The millimeters of aluminum values reported in this study were 10.41 ± 0.5, 8.20 ± 1.0, 6.50 ± 0.5, 4.90 ± 0.2, and 3.09 ± 0.1 for AH Plus, Epiphany, Diaket, GuttaFlow, and Adseal, respectively, which were significantly different from each other ($p < .001$). All materials showed radiopacity above 3 mm of aluminum recommended by ISO and ANSI/ADA Specification 57.

Discussion

A root filling material should ideally be radiopaque to enable visualization and assessment on the radiograph. Therefore, newly developed root canal filling materials and sealers should be investigated in this respect. The ISO and ANSI/ADA require a minimal radiopacity equivalent to 3 mm of aluminum. According to the present results, AH Plus, Epiphany, Diaket, and GuttaFlow proved to be sufficiently radiopaque, whereas Adseal showed only minimum requirements of international standards.

The aluminum stepwedge was chosen as the standard for measuring radiopacity because it allows comparison of specific sample thicknesses of aluminum stepwedge under typical radiographic conditions (14). The digital radiography was used for the evaluation of the radiopacity of the root canal pastes/sealers in the present study. Radiographic software allows for a more detailed analysis of the digital image, which is shown on a computer screen and can be evaluated graphically or by the grey-pixel value (20). In addition to reducing the operator's potential exposure to radiation and eliminating the need for film development chemicals, digital radiography also provides consistency. Traditional film development, unless performed carefully, can produce significant variations in the final radiograph. Thus, a digital method should provide more consistent results (22).

The results are difficult to compare with those of previous studies of the radiopacity of endodontic sealers because the choice of imaging

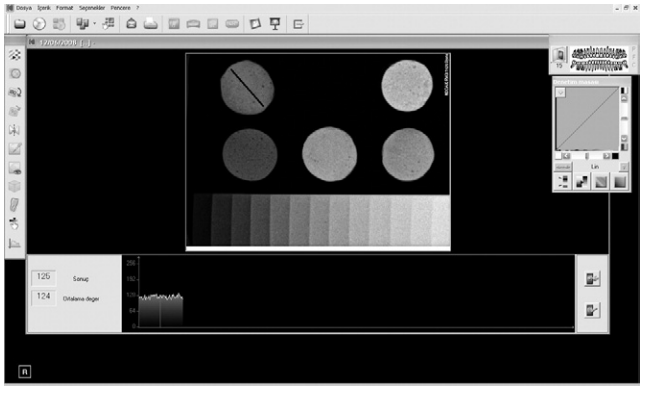


Figure 1. Computer screen during the measurement of the radiopacity of materials by the Kodak dental imaging software 6.7.

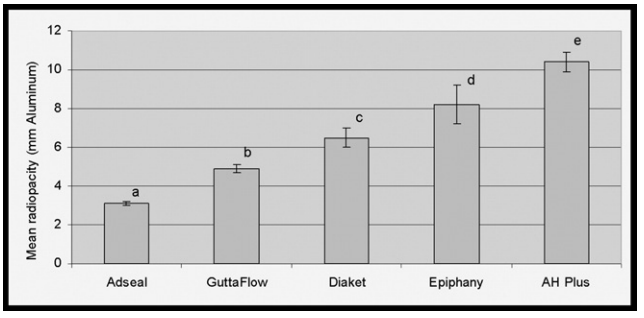


Figure 2. Comparative radiopacities expressed in mean equivalent aluminum thickness ± standard deviation for the materials. Entries with the variant capital letter were significantly different ($p < .001$).

device can affect the measured radiopacity of a material. Modern digital sensor systems use slightly different methods of measuring x-ray radiation so it is possible that the radiopacity as recorded on film is not indicative of the radiopacity as recorded on a digital sensor (21). In this study, the radiopacity of AH Plus sealer was found as 10.41 mm of aluminum; it was 11.2 (20), 9.8 (18), and 9.0 (15) mm of aluminum in previous studies. We have found the radiopacity of Epiphany sealer to be 8.2 mm of aluminum, whereas it was found in to be 10.35 mm of aluminum (14) by densitometric analysis, 8.8 (18) by digitized film, 8.0 (20) by Digora digital radiography (Soredex Orion Corp., Helsinki, Finland), and 7.34 (21) by Gendex digital radiography (Gendex Dental Systems, Milan, Italy).

There was no report in the literature about the radiopacity of GuttaFlow, which is a new root canal paste, while this study was performed. However, the present results are in agreement with previous reports that evaluated the radiopacity of the previous formulation of this material called RoekoSeal. In this study, the radiopacity of GuttaFlow was found as 4.9 mm of aluminum, whereas in those studies the radiopacity of Roekoseal was found as 5.7 (18), 5.6 (15), 4.95 (21), and 4 (17) mm of aluminum. Baksı Akdeniz et al. (4), using a different methodology, reported that Roekoseal masked the present radiopacity of the gutta-percha cones, particularly at the apical part of simulated root fillings. According to their results, Diaket increased the radiopacity of the fillings. Adseal was found to have the lowest radiopacity value (3.09 mm of aluminum) among the sealers that were examined in this study. However, it still satisfied the international minimum standards of 3 mm of aluminum. The reason for this lack of radiopacity associated with Adseal may be an inadequate radiopaque material or insufficient concentration within the sealer.

According to the results of the present study, GuttaFlow paste with its 4.9 mm of aluminum radiopacity has denoted a radiopacity that is above the minimum radiopacity level determined by the ISO and ANSI/ADA. On the other hand, Adseal, which is a new root canal sealer, has ensured the minimum international standards at the limit level with its 3.09 mm of aluminum radiopacity value.

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