Revista Odonto Ciência
Journal of Dental Science

ORIGINAL ARTICLE

Rev Odonto Cienc 2015;30(3):81-84
http://revistaseletronicas.pucrs.br/ojs/index.php/fo
doi: http://dx.doi.org/10.15448/1980-6523.2015.3.13632

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# *In vitro* evaluation of radiopacity of different filling materials by resources of digital radiography

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## Abstract

**Objective:** The purpose of this study was to evaluate the radiopacity of different filling materials, using resources of digital radiography in a human tooth model.

**Methods:** Seventy extracted single-rooted human teeth were selected, the coronal access was performed, and the working length was established 1 mm short of the foramen. After chemo-mechanical preparation the teeth were divided into 7 groups [n=10] according to the filling material used: G1 Epiphany, G2 AH Plus, G3 EndoRez, G4 EndoFill, G5 Endomethasone, G6 Sealapex and G7 Sealer 26. In the G1 Epiphany system, Resilon cones were used; however, in all other groups gutta-percha cones were used. After seven days of storage, digital radiographs were taken to assess the results. To evaluate the radiopacity, the digital software DBSWIN generated a colorimetric graphic for each sample, correlating the color gradient observed in the sample with a corresponding numerical score. The data were statistically analyzed by ANOVA and Tukey's test at 5% significance level.

**Results:** The system Epiphany / Resilon was statistically superior to the AH Plus, EndoRez, Sealapex and Sealer 26 groups associated with gutta-percha in terms of radiopacity [P<0.05].

**Conclusion:** The root canal sealer Epiphany, associated with Resilon cones, showed the highest values of radiopacity.

**Key words:** Filling; Filling materials; Radiopacity

## Avaliação *in vitro* da radiopacidade de diferentes materiais obturadores através de recursos de radiografia digital

### Resumo

**Objetivo:** Avaliar a radiopacidade de diferentes sistemas obturadores endodônticos por meio de radiografia digital em um modelo de dentes humanos.

**Metodologia:** Setenta dentes humanos unirradiculares extraídos foram selecionados, a abertura coronária foi feita e o comprimento de trabalho foi determinado 1 mm aquém do forame apical. Após o preparo químico-mecânico os dentes foram divididos em 7 grupos [n=10] de acordo com o material obturador utilizado: G1, Epiphany; G2, AH Plus; G3, EndoRez; G4, EndoFill; G5, Endomethasone; G6, Sealapex; G7, Sealer 26. No G1 foram utilizados cones de Resilon e nos demais grupos cones de guta-percha. Sete dias após a obturação foram feitas radiografias digitais e as imagens foram introduzidas num software para a leitura dos resultados. Para avaliar a radiopacidade, o software digitale DBSWIN gerou um gráfico colorimétrico para cada amostra, relacionando o gradiente de cor observado na amostra com o respectivo escore numérico contido em uma escala desse gráfico. Os dados foram analisados estaticamente pelo teste ANOVA e Tukey's ao nível de 5% de significância.

**Resultados:** O sistema Epiphany/Resilon foi superior estatisticamente aos grupos do AH Plus, EndoRez, Sealapex e Sealer 26 em termos de radiopacidade [P<0,05].

**Conclusão:** O cimento endodôntico Epiphany, associado aos cones Resilon, apresentou os maiores valores de radiopacidade.

**Palavras-chave:** Obturação; Materiais obturadores; Radiopacidade

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**Received:** April 29, 2013
**Accepted:** July 2, 2015

**Conflict of Interests:** The authors state that there are no financial and personal conflicts of interest that could have inappropriately influenced their work.

## Introduction

Filling of the root canal system is usually performed using a combination of sealer and gutta-percha. Gutta-percha is widely used due to satisfactory physical and biological properties [1]. However, the lack of adherence of gutta-percha to both the canal walls and cement is a major disadvantage. As a result, sealer must be used to establish intimate adaptation of the gutta-percha to the dentinal walls [2].

Endodontic filling materials of all types must meet certain requirements to be considered adequate. An ideal root canal filling material must provide, among other physical and chemical properties, adequate radiopacity. This propertie allows the distinction of the filling material from adjacent anatomical structures [3,4] such as bone and teeth [5]. Furthermore, the radiopacity of endodontic filling systems has been of particular significance for assessing the quality of endodontic treatment and detecting possible voids in the filling [6].

Several *in vitro* models have been proposed to evaluate the radiopacity of endodontic filling systems. However, these models have some limitations. As to the evaluation of radiopacity, samples of the materials tested are prepared in molds or dies to obtain standardized discs [7]. Conventional radiographs [8], radiographic densitometry [9] or digitalization of conventional radiographs [10,11] may be used to measure the results of samples prepared in either molds or dies. However, these models do not accurately represent the clinical and anatomic features of the tooth, in vivo. On this way, the evaluation methods may not be sufficiently accurate to carry out the measurements.

The aim of this study was to evaluate, in vitro, the the radiopacity of seven different systems of endodontic filling material in extracted human teeth as measured by software quantitative analysis of digital radiographs.

## Materials and Methods

Seventy extracted maxillary central incisors were used for this study. The coronal portion of the teeth was removed using a diamond disc at low speed under irrigation and a standard length of 15 mm was achieved for each sample.

The coronal and middle thirds of root canals were prepared with Gates-Glidden burs # 3 and # 2 (Dentsply Maillefer). The working length was established by subtracting 1 mm from the measurement obtained by placing a K-type file number 10 (Dentsply Maillefer) inside the root canal until the tip could be seen at the foramen. The canals were instrumented up to a size #45 (Dentsply-Maillefer) by the manual instrumentation through step-back preparation. After every change of drill or file, the canals were irrigated with 2 ml of 2.5% sodium hypochlorite. After chemo-mechanical preparation, 3 ml 17% EDTA were used to remove the smear layer; a final wash with 5 ml of saline solution was administered. The canals were dried with absorbent paper points, concluding the protocol.

Before the filling of root canals, the samples were mounted in blocks of alginate (Dentsply, Petrópolis, RJ, Brazil) to confine the sealer after their flow in an attempt to simulate the periodontal ligament. The samples were then randomly divided into seven groups (n=10) according to the endodontic filling system used: Group 1 – Resilon/Epiphany, Group 2 – gutta-percha/AH Plus, Group 3 – gutta-percha/EndoRez and Group 4 – gutta-percha/Endofill, Group 5 – gutta-percha/Endomethasone, Group 6 – gutta-percha/Sealapex and Group 7 – 26 gutta-percha/Sealer. In all groups, the sealer was introduced into the root canal with the aid of a spiral Lentulo number 40 (Dentsply Maillefer) and the filling was done by lateral condensation. For this procedure, the master cone, coated with sealer, was fitted inside the root canal; lateral condensation was performed with digital spacers 25 and 30 (Dentsply Maillefer); and accessory cones B7/B8 (Tanari, Manaus, AM, Brazil) were introduced to complete the filling. Excess gutta-percha was removed with a heated instrument, and cold pluggers were used to vertically condense the gutta-percha. In group 1, an absorbent paper cone coated with primer was introduced into the root canal at the working length prior to completion of lateral condensation, promoted with Resilon cones and Epiphany sealer. After applying the primer and before the removal of excess filling material, the samples were photoactivated for thirty seconds. After being filled, all groups were stored for 48 hours in high humidity at a temperature of 37 °C to allow the sealers to set.

After 48 hours, the alginate blocks were removed and digital radiographs were made using digital x-ray Spectro 70x [Dabi Atlante, Ribeirão Preto, SP, Brazil] at 70kVp, 10 mA and 0.20 seconds of exposure time, at a focal length 30 cm. A positioner was used to maintain a radiation pattern perpendicular to the long axis of the tooth. The processing was developed in the automatic processing machine Vista-Scan (Dürr Dental, Bietigheim, Deutschland) and the radiographic images obtained were entered into the software program DBSWIN (Dürr Dental, Bietigheim, Deutschland) to read the results through quantitative analysis.

To evaluate the radiopacity, scanned images of each sample were analyzed in the manner described above and were further analyzed with the colorimetric graphic contained in the software (Figure 1A-C). Colors were quantified on a scale of 1 to 7, with 1 representing black and 7 representing white. Scores of 2 to 6 represented gradients of grayscale in between. In other words, scores of 1 represented radiolucency, and scores of 7 represented radiopacity.

The root of each tooth sample, of all groups, was divided into thirds; scores were assigned for each third and were then averaged with the other scores for each tooth. These calculations provided the mean absolute optical density of each sample. The mean of each group allowed comparison of the degree of radiopacity among the different systems of filling material. The numerical scores were assigned by two examinors, previously calibrated, who were blinded to the identification of filling system sused.

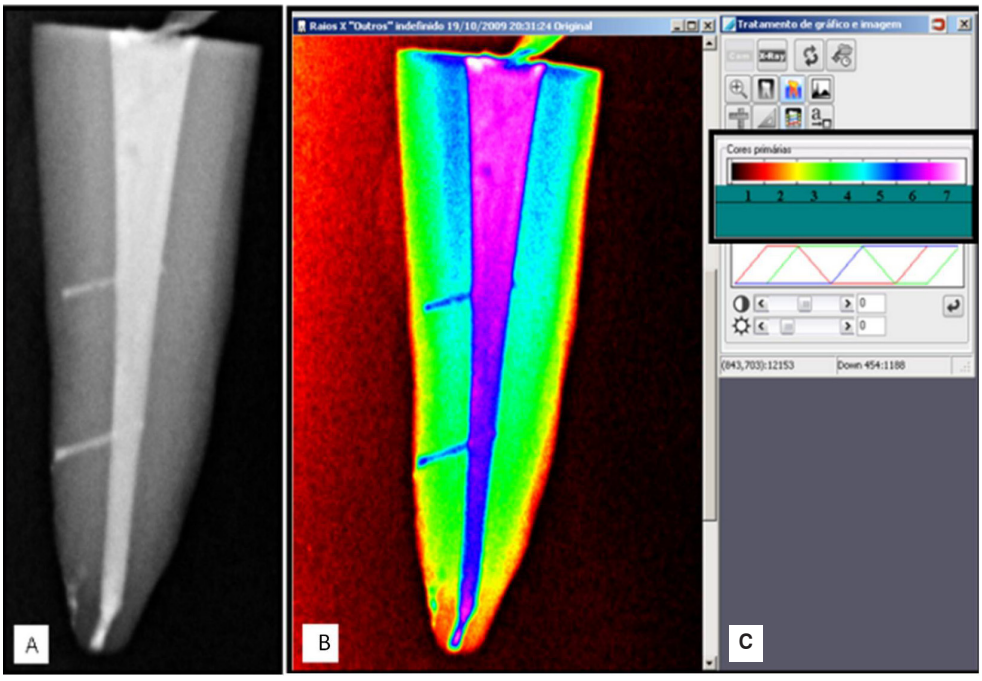


**Figure 1.** (A) digital radiography of the obturated main canal; (B) colorimetric scale for measuring the radiopacity of the filling materials.

Data from radiopacity were statistically analyzed using analysis of variance (ANOVA) and Tukey test with a significance level of 5%.

## Results

The mean and standard deviation of radiopacity in each group are presented in Table 1. Statistical analysis showed that the filling systems Endofill/gutta-percha and Endomethasone/gutta-percha were statistically similar to other groups with respect to the degree of radiopacity ($p>0.05$). The filling system Epiphany/Resilon revealed superior radiopacity to the systems AH Plus/gutta-percha, EndoRez/gutta-percha, Sealapex/gutta-percha and Sealer 26/gutta-percha ($p<0.05$).

**Table 1.** Mean and standard deviation of radiopacity for each group

| Groups | Mean and standard desviation |
|---|---|
| Epiphany and Resilon | 6.64±0.12a |
| AH Plus and Gutta-percha | 6.15±0.21b |
| EndoRez and Gutta-percha | 6.09±0.53b |
| EndoFill and Gutta-percha | 6.41±0.31ab |
| Endomethasone and Gutta-percha | 6.33±0.22ab |
| Sealapex and Gutta-percha | 6.21±0.24b |
| Sealer 26 and Gutta-percha | 6.14±0.30b |

## Discussion

When considering the various properties of a root canal filling material which make a material appropriate, adequate radiopacity has significant importance. Radiopacity is important because it allows the distinction between the endodontic filling material and adjacent anatomical structures [3,4], such as bone and teeth [5] and it allows evaluation of the quality of endodontic treatment, detecting possible spaces in the filling [6].

Different models have been proposed for assessing the radiopacity of various endodontic filling materials. Most of these models involve sets of identical acrylic plates which are filled with different samples of sealer materials. Radiographs are taken of the samples and the radiopacity of the sealers are compared to that of a stepwedge calibrated in millimeters [mm] of aluminium [12-14], according to the specification number 57 of the ADA [15].

This study proposes the introduction of different systems of filling materials into the root canal to evaluate the radiopacity of each system. On this way, digital x-ray software simulates the naturally occurring conditions, position and adaptation of filling systems into the root canal.

The resources such as radiographic densitometry [6,9,16] and digitalization of conventional radiographs [10-12] have been used in previous studies to evaluate the radiopacity of different filling materials. Other studies have used color gradients contained in a calibrated stepwedge, in mm of aluminum, to compare results. This study employed the use of a digital x-ray software program used in previous studies [12-14,17]. This method allowed a more precise quantitative analysis from the images introduced in the software. By generating a colorimetric chart for each sample, absolute mean values of the radiopacity of each filling material were obtained. This allowed comparison of the degree of radiopacity among the samples in a straightforward manner, similar to the previous study [18].

Regarding the radiopacity, the results of this study showed that the filling system Epiphany/Resilon was superior to the systems AH Plus/gutta-percha, EndoRez/gutta-percha, Sealapex/gutta-percha and Sealer 26/gutta-percha ($p<0.05$). These results contradict the findings, which stated that the root canal sealers AH Plus and Epiphany had the greatest degree of radiopacity, without a statistically significant difference between them ($p<0.05$), as evaluated with digital radiography [12]. The high degree of radiopacity of the filling system Epiphany/Resilon can be explained by the filler components found in the composition of the Resilon cones. In a previous study, which evaluated the radiopacity of endodontic materials using digital radiography, it was found that Resilon cones showed higher radiopacity compared to gutta-percha cones and sealers AH Plus, Endofill, EndoRez and Epiphany [13]. While bioactive glass, barium sulfate, bismuth oxychloride and "red iron oxide" are included as filler components in both the inner core and outer surface of Resilon cones, these components are absent in the gutta-percha cones. This difference in composition may contribute for increased radiopacity found in the Epiphany/Resilon system. The components which provide structural strength of the material makes up approximately 65%, by weight, of gutta-percha [19], which may explain the high degree of radiopacity. Furthermore, the root canal sealer Epiphany contains silane-treated barium borosilicate glass in addition to barium sulfate, bismuth and silica which, according to the manufacture, provide a significant radiopacity to the material [19]. Our study evaluated the radiopacity of endodontic filling systems consisting of set sealer and cones, rather than just sealer as in previous studies. This difference in sampling design may explain the difference seen between previous published results and the major radiopacity attributed to system Epiphany/Resilon.

## Conclusion

Within the limitations of this study was determined that the root canal sealer Epiphany associated with Resilon cones had the highest values of radiopacity.

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