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Original Research Article

Evaluation of the influence of bioceramic sealers on the radiopacity of single-cone fillings

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Abstract

Introduction: Radiopacity is an essential physical property to measure the quality of the filling, and whether the association of bioceramic sealers with gutta-percha cones increases the radiopacity of the filling was not previously assessed. **Material and methods:** Sixty transparent resin blocks with simulated root canals were prepared and X-rayed with a gutta-percha cone. The blocks were divided into five groups and filled with the single-cone technique using AH Plus (Dentsply Sirona, Ballaigues, Switzerland), AH Plus Bioceramic (Dentsply Sirona, Ballaigues, Switzerland), Bio-C Sealer (Angelus, Londrina, Brazil), BioRoot RCS (Septodont, Saint Maur-des-Fosses, France), or Sealer Plus BC (MK Life, Porto Alegre, Brazil). New radiographs were taken, and the images were analyzed using the Adobe Photoshop software (Adobe Systems Inc., San Jose, USA). **Results:** There was no difference ($p>0.05$) in the radiopacity of the gutta-percha cones used in the five groups. The epoxy resin-based AH Plus and AH Plus Bioceramic showed the highest increase in radiopacity ($p<0.05$). Sealer Plus BC, BioRoot RCS, and Bio-C Sealer showed similar radiopacity ($p<0.05$). **Conclusion:** All sealers showed increased radiopacity ($p<0.05$) when associated with the gutta-percha cone.

Introduction

Filling the root canal system is an important stage of endodontic treatment, which, after the stages of cleaning and shaping, helps to prevent bacterial reinfection [8] by entombing the residual bacteria of the dentinal tubules and preventing the entry of fluids and new bacteria into the root canal systems [6].

Gutta-percha has been chosen as a solid filling material for root canal filling because it has no toxicity, low allergenic potential, and minimal tissue irritability [19]. However, gutta-percha does not have adhesiveness to the walls of the root canal, requiring its use together with a fluid material, such as sealers, which aim to fill voids and irregularities in the root canal, lateral and accessories canals, and spaces between gutta-percha cones used in lateral condensation techniques [9].

AH Plus (Dentsply Sirona, Ballaigues, Switzerland), an epoxy resin-base sealer, is considered the gold standard nowadays [8, 10, 13] because it features low solubility, adequate radiopacity, excellent dimensional stability, long-lasting sealing, and antimicrobial action [4, 6, 13, 14]. However, there are concerns about the relatively high cytotoxicity of epoxy resin-based sealers [8].

Bioceramic sealers have attracted attention for their physicochemical and biological properties, as they have alkaline pH, antibacterial activity, adequate radiopacity, biocompatibility, and absence of toxicity [4]. Due to its excellent properties, several bioceramic sealers have been introduced to the market by different manufacturers, such as Sealer Plus BC (MK Life, Porto Alegre, Brazil), Bio-C Sealer (Angelus, Londrina, Brazil), BioRoot RCS (Septodont, Saint Maur-des-Fosses, France), and AH Plus Bioceramic (Dentsply Sirona, Ballaigues, Switzerland) (table I).

ISO 6876: 2012 establishes that a filling material must have a radiopacity equivalent to the thickness of 3 mm of aluminum, and the radiographic image should be obtained through chemical processing and the radiopacity evaluated using an optical densitometer [16]. The chemical processing requires more time and can interfere with the final quality of the radiographic image, however, with the use of digital radiography, the use of chemical solutions for image processing is no longer needed [5]. Also, with the use of software, it is possible to obtain a more detailed analysis of radiographic images [5].

Considering that radiopacity is an essential physical property to measure the quality of the filling [4], and that the AH Plus Bioceramic, Sealer Plus BC, Bio-C Sealer, and BioRoot RCS sealers already have studies showing that these sealers have radiopacity greater than 3 mm of aluminum [8, 10, 15, 18], but have no studies in vitro evaluating the radiopacity of sealer associated with gutta-percha cones, this study aimed to assess the increase in radiopacity of different bioceramic sealers in single-cone fillings in simulated canals, using digital radiography.

Table I – Composition of endodontic sealers according to the manufacturer

	Composition	**Radiopacifier**
AH Plus	Paste A: bisphenol-A epoxy resin, bisphenol-F epoxy resin, calcium tungstate, zirconium oxide, silica, iron oxide pigments Paste B: dibenzyldiamine, aminoadamantane, tricyclodecane-diamine, calcium tungstate, zirconium oxide, silica, silicone oil	Calcium tungstate, zirconium oxide, iron oxide
AH Plus Bioceramic	Zirconium dioxide, tricalcium silicate, dimethyl sulfoxide, lithium carbonate, bentonite clay, polyvinyl alcohol and polyvinylpyrrolidone	Zirconium dioxide
Bio-C Sealer	Tricalcium silicate, dicalcium silicate, tricalcium aluminate, calcium oxide, zirconium oxide, silicon oxide, polyethylene glycol, iron oxide	Zirconium oxide, iron oxide

To be continued...

Continuation of table I

	Composition	Radiopacifier
BioRoot RCS	Powder: tricalcium silicate, zirconium oxide, povidone Liquid: aqueous solution of calcium chloride and polycarboxylate	Zirconium oxide
Sealer Plus BC	Calcium silicate, zirconium oxide, tricalcium silicate, calcium silicate, calcium hydroxide	Zirconium oxide

Material and methods

Sixty transparent resin blocks with simulated root canals of 17 mm long and 60° of curvature angle (IM do Brasil, São Paulo, Brazil) were used. The canals were prepared with nickel-titanium rotary instruments from the Pro-T System (MKLife, Porto Alegre, Brazil) to the F3 (30/.09) instrument using an X-Smart Plus electric motor (Dentsply Sirona, Ballaigues, Switzerland) at 350 rpm and 1.5 N torque. Root canals were irrigated with 1% sodium hypochlorite solution after using each instrument. After the final irrigation, the canals were dried using capillary tips (Ultradent, South Jordan, USA) and paper points. An F3 (30/.09) gutta-percha cone (Dentsply Sirona, Ballaigues, Switzerland) was adapted in the simulated canal.

Then, each block was placed in the central region of a digital radiography sensor (RVG 5000, Eastman Kodak Company, Rochester, USA) and X-rayed with a Heliodent 60 B X-ray machine (Siemens, Bershein, Germany), with 60 kVp, 10 mA, 0.16 seconds of exposure time, and with a standardized sensor-focus distance of 12 cm.

The blocks were divided into five groups (n=12) and filled with the single-cone technique using AH Plus (Dentsply Sirona, Ballaigues, Switzerland), AH Plus Bioceramic (Dentsply Sirona, Ballaigues, Switzerland), Bio-C Sealer (Angelus, Londrina, Brazil), BioRoot RCS (Septodont, Saint Maur-des-Fosses, France), or Sealer Plus BC (MK Life, Porto Alegre, Brazil).

The sealers were used according to their presentation. For the AH Plus, equal amounts of paste A and paste B were mixed on a glass plate until a homogeneous consistency was obtained, and then the sealer was inserted into the canal using the F3 gutta-percha cone and making brushing movements. The AH Plus Bioceramic and Bio-C Sealer were injected into the canal with a proper applicator cannula. The Sealer Plus BC and BioRoot RCS were mixed according to the manufacturer's instructions and inserted into the canals using the F3 gutta-percha cone and making brushing movements. The gutta-percha cones were inserted in the simulated canals.

The filling was cut using a heated hand plugger, followed by vertical condensation using a cold hand plugger. The samples were stored in an oven at 37°C, with 100% humidity, for 48 hours.

After this period time, new radiographs were taken using the same initial parameters.

The images were analyzed using Adobe Photoshop version 25.5.1 (Adobe Systems Inc., CA, USA). The area of the gutta-percha cone was selected, and the mean gray value, in pixels, was recorded. To evaluate the filling, the gutta-percha cone itself was the control. Thus, the same initially measured area of the cone was superimposed on the filling to record the gray value of the filling (figure 1).

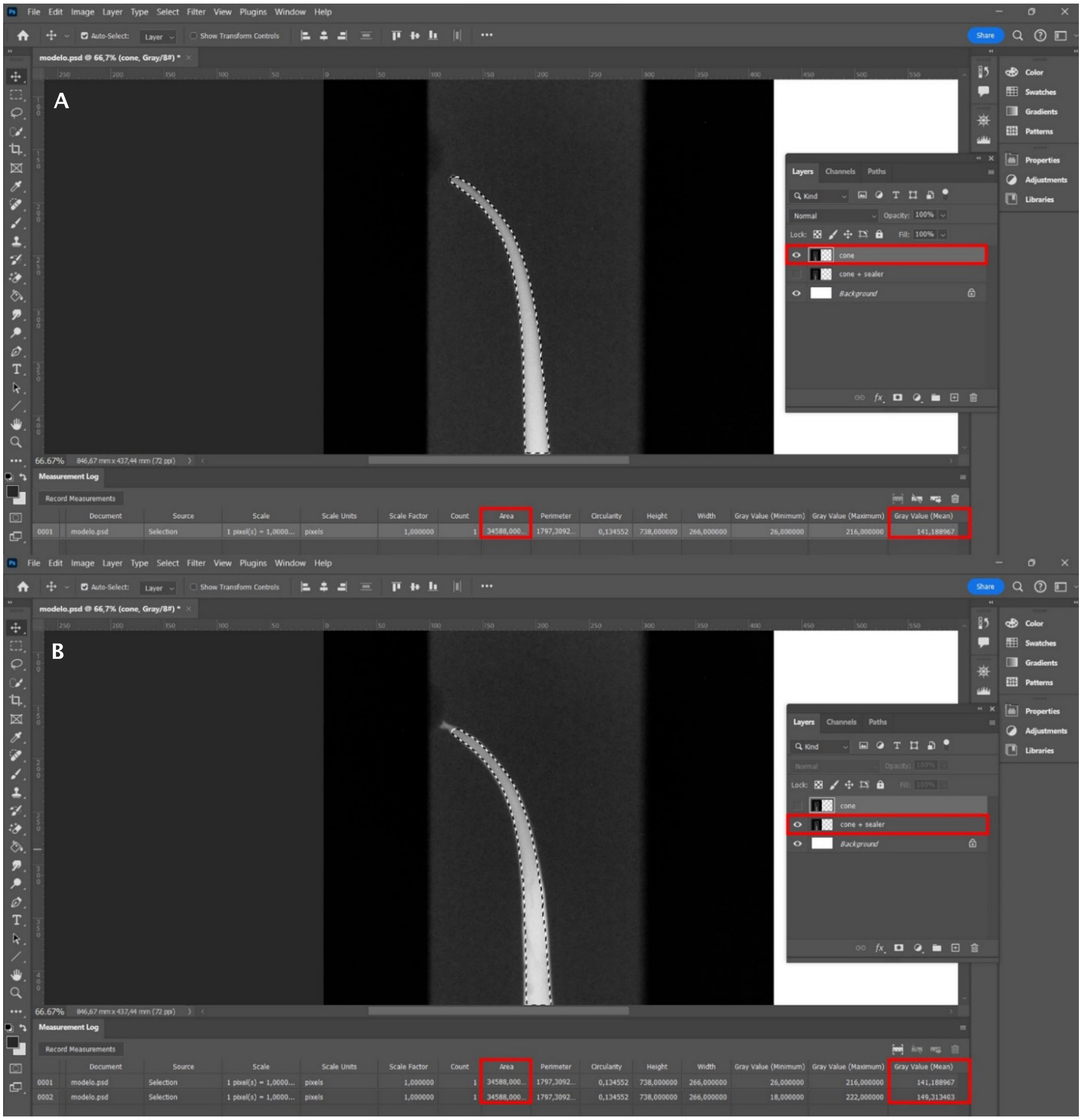

Figure 1 – A) Print screen of the Adobe Photoshop software interface showing how the measurements of the mean gray value of the gutta-percha cone only; B) the association of the gutta-percha cone with sealer were made. The same evaluated area and the gray value are highlighted in red.

Results

Shapiro-Wilk and D'agostino-Pearson tests were used to verify the normal distribution. For intragroup analyses, the paired t-test was used, and for intergroup analyses, the Anova test and the Tuckey test for multiple comparisons were used.

There was no difference ($p>0.05$) in the radiopacity of the gutta-percha cones used in the five groups.

The AH Plus and AH Plus Bioceramic sealers showed a greater increase in radiopacity ($p<0.05$) when compared with the other sealers and had no difference between them ($p>0.05$). The Bio-C Sealer, BioRoot RCS, and Sealer Plus BC showed no difference between them ($p>0.05$) (tables II and III).

Table II – Mean ± standard deviation for radiopacity values (in pixels) of gutta-percha cones and gutta-percha cones with the addition of sealer

	AH Plus	AH Plus Bioceramic	Bio-C Sealer	BioRoot RCS	Sealer Plus BC
Gutta-percha cone radiopacity	143.4 ± 1.30aA	142.9 ± 0.71aA	142.7 ± 0.45aA	143.0 ± 0.58aA	143.0 ± 0.71aA
Gutta-percha cone + sealer radiopacity	152.2 ± 2.06aB	151.2 ± 0.86aB	144.9 ± 0.8bB	145.5 ± 1.10bB	144.8 ± 0.63bB

Different superscript lowercase letters in each row indicate intergroup statistically significant differences (p<0.05). Different superscript uppercase letters in each column indicate an intragroup statistically significant difference (p<0.05)

Table III – Mean ± standard deviation regarding the increase in radiopacity provided by sealer (percentage)

	AH Plus	AH Plus Bioceramic	Bio-C Sealer	BioRoot RCS	Sealer Plus BC
% increase in radiopacity	6.2 ± 1.92[a]	5.8 ± 0.92[a]	1.6 ± 0.68[b]	1.8 ± 0.62[b]	1.3 ± 0.47[b]

Different superscript lowercase letters in each row indicate intergroup statistically significant differences (p<0.05)

Discussion

The constant development of new filling materials aims to improve the sealing of the root canal system since three-dimensional sealing of root canals contributes to the success of endodontic treatment [9].

Bioceramic sealers are a combination of calcium silicate and calcium phosphate, resulting in a material with the ability to form hydroxyapatite during the setting process and a bond between the dentin and the filling material [4, 10].

The radiopacity of sealers is an important means for assessing the quality of endodontic treatment, which should allow a clear distinction between the materials and the surrounding anatomical structures [1, 5, 10], as well as being useful in assessing possible voids in the fillings [2].

In this study, digital radiography and Adobe Photoshop software were used for radiopacity analysis. The use of digital radiography to evaluate the radiopacity of materials has proved satisfactory since it is possible to immediately obtain the image, and the radiopacity can be evaluated by gray pixel values [3, 5].

AH Plus, an epoxy resin-based sealer, along with AH Plus bioceramic, had the highest increase in radiopacity when compared to the other bioceramic sealers evaluated. Several studies [4, 7, 10, 11, 15, 18] that compared the radiopacity of AH Plus with bioceramic sealers also found this higher radiopacity, which can be attributed to its composition, a combination of zirconium oxide with calcium tungstate [10].

The high radiopacity of AH Plus Bioceramic can be attributed to the radiopacifier zirconium dioxide in high concentration (50 – 70%) [8]. In this study, no difference was found between AH Plus and AH Plus Bioceramic, as found in another study as well [13], however, other studies have found that despite the two being more radiopaque than other bioceramic sealers, AH Plus still showed higher radiopacity [8, 17].

The Bio-C Sealer, BioRoot RCS, and Sealer Plus BC showed no difference between them. While some studies show that Bio Root RCS has low radiopacity when compared to AH Plus [7, 15], another study found no difference [12]. The Bio-C Sealer presented lower radiopacity when compared to the AH Plus [8, 11, 18], as well as the Sealer Plus BC [10]. These three sealers also feature zirconium oxide [7, 8, 10], but the difference in radiopacity may be related to the concentration of this radiopacifying agent in each formulation.

The gutta-percha cones did not present radiopacity differences in the groups, showing that they did not influence the radiopacity differences found in the groups after the association with the sealers. In addition, all sealers showed increased radiopacity when associated with the gutta-percha cone in relation to the control, which was the gutta-percha cone itself.

In this study, the radiopacity in the different millimeters of the filling was not evaluated, but a study that performed this analysis found that with the decrease in the diameter and relative thickness of the gutta-percha, the radiopacity also decreased, showing that the radiopacity of the sealer became the main component that affects the overall opacity of the root filling, particularly in the apical third [2].

The radiopacity of endodontic sealers is an important property to be studied, as it helps to assess the length and homogeneity of the fillings. Future studies that evaluate the radiopacity of these sealers associated with gutta-percha cones are needed in clinical conditions, as well as studies that consider the solubility of the sealers and evaluate the radiopacity in the long term.

Conclusion

The addition of AH Plus Bioceramic, Bio-C Sealer, BioRoot RCS, and Sealer Plus BC increased the radiopacity of the filling with gutta-percha cone. The AH Plus and AH Plus Bioceramic sealers showed a greater increase in radiopacity.

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