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COMPARATIVE RADIOGRAPHIC ASSESSMENT OF A NEW BIOCERAMIC-BASED ROOT CANAL SEALER

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Abstract

Background and aims. *The aim of this study was to assess the radiopacity of two bioceramic-based root canal sealers, the conventional TotalFill BC sealer (FKG Dentaire Switzerland) and a new experimental filling material developed in collaboration with 'Raluca Ripan' Institute for Research in Chemistry, Cluj-Napoca.*

Methods. *Five disc samples were prepared using both materials (10 mm diameter x 1 mm thickness), being subjected to digital radiography together with aluminum step wedges (1 to 12 mm in thickness), in accordance with ISO 6876: 2012. Radiopacity was determined by the computer analysis of the images obtained. Four different areas were selected for each sample, corresponding to a disk-sample quadrant. Statistical analysis was performed using ANOVA.*

Results. *Both materials showed a radiopacity that was 3 mm greater than the equivalent thickness of aluminum. Total Fill BC showed greater radiopacity than the experimental material, but the differences were not statistically significant.*

Conclusions. *Both materials comply with ISO 6876: 2012 recommendations on minimum radiopacity.*

Keywords: radiopacity, bioceramic materials, root canal sealer, digital radiography, aluminum step wedge

Introduction

Since the first studies on the prognosis of root canal treatments, the quality of the filling material was considered essential to their success [1]. The presence of voids in the filling mass was associated with bacterial proliferation and the development of periapical lesions [2].

Among the most important factors influencing the quality of the treatment are certainly the sealers [3,4,5,6]. These materials should be biocompatible [7,8] and they must have the adequate physicochemical [9,10] and antimicrobial properties [11].

In this context, it is important to study the properties of root canal filling materials in order to determine the optimum parameters for the development of new ones and to evaluate those that are already on the market.

Among other physicochemical properties, the ideal root canal sealer should present sufficient radiopacity to be distinguished from adjacent anatomical structures, such as dental tissue or jaw bone [12,13]. Higginbotham [14] was the first researcher who published a comparative study on the radiopacity of different root canal fillings and gutta-percha cones used in root canal treatment. Eliasson and Haasken [15] have established a comparison standard for radiopacity

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studies using optical density values for impression materials and calculating the equivalent thickness of aluminum required to result in similar radiographic density. Beyer-Olsen and Orstavik [16] introduced a comparison standard using an aluminum step wedge with 2-mm increments in thickness to evaluate the radiopacity of root canal sealers.

In 1983, The American National Institute for Standards and Technology (NIST) and The American Dental Association (ADA) issued a series of rules and tests - called Specification no. 57 - to assess the physicochemical properties of root canal sealers in an attempt to standardize their testing and promote quality in dental materials research. This specification was revised in 2000 and includes the following tests: film thickness, setting time, flow, radiopacity, solubility and dimensional change following setting [17].

Due to the diversity of composition of the available sealers and considering the ANSI/ADA standards, the purpose of this study was to evaluate the radiopacity of two bioceramic-based root canal sealers.

Material and methods

In this study we evaluated the radiopacity of two bioceramic root canal sealers, one that is already on the market - Total Fill BC sealer (FKG Dentaire Switzerland) and a new experimental filling material developed in collaboration with 'Raluca Ripan' Institute for Research in Chemistry, Cluj-Napoca (Table I).

Five disc-shaped samples were prepared from each material (10 mm diameter x 1 mm thickness) according to manufacturers' instructions. The samples were stored at 37°C and 95% humidity until the final adhesion [18].

Pure aluminum step wedges with a thickness ranging from 1 to 12 mm were used as standards. The purity of the graded standard used in this study, as measured by optical spectroscopy, was 99.52% Al, 0.22% Fe and 0.001% Cu, in accordance with the recommendations in the literature [19].

The discs were placed together with standard aluminum on an in vitro intraoral sensor (Figure 1). Digital radiographic images (Figure 2) were obtained using an XIOS Plus (Sirona) intraoral sensor system and a Soredex (Minray) X-ray unit at 70 kV, 7 mA, 0.32 seconds exposure time at a focal length of 30 cm.

Radiopacity was determined by digitally processing the radiographed discs using a computer application (Figure 3) [20]. Four areas have been selected for each sample, corresponding to a different quadrant (quadrants I, II, III, IV) of the prepared disc. The area of choice involved an area where no air bubbles are present and the homogeneity - determined using the same applications - meets the standard (minimum 30% homogeneity) (Figure 4).

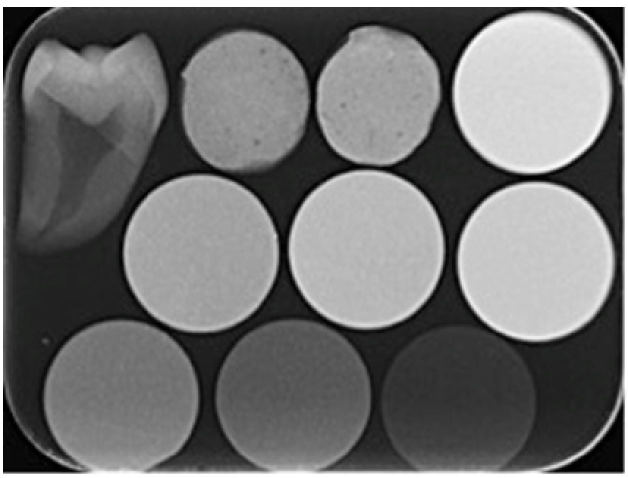

Figure 1. Positioning discs and standards on the sensor.

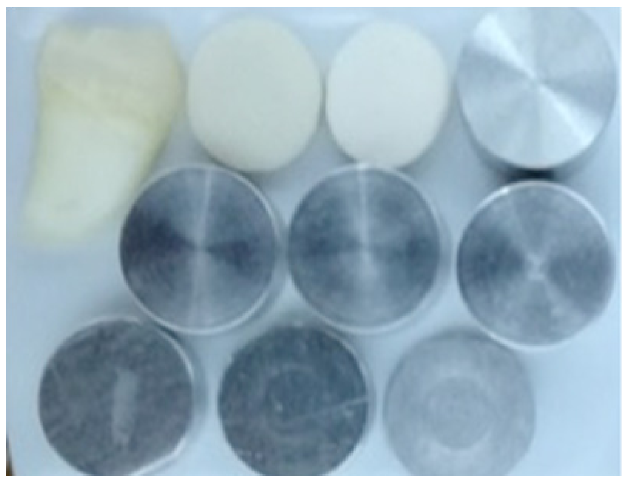

Figure 2. Digital radiographic images of samples and standards.

Table I. Chemical composition of the two materials.

Sealer	Composition
Total Fill	Zirconium oxide (35-45%), tricalcium silicate (20-35%), dicalcium silicate (7-15%), calcium hydroxide (1-4%)
Experimental material	Hydroxyapatite with silver (10-15%), Hydroxyapatite with zinc (5-10%), Zirconium oxide (10-15%), aluminosilicate glasses (45-50%), calcium hydroxide (5-10%)

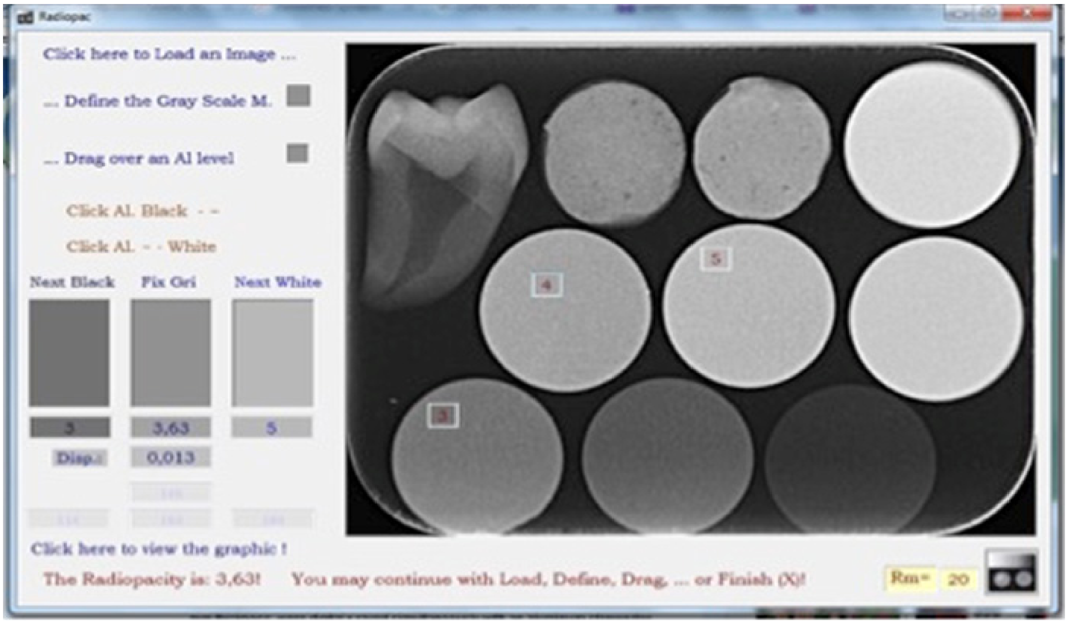

Figure 3. Determining the radiopacity using computer software.

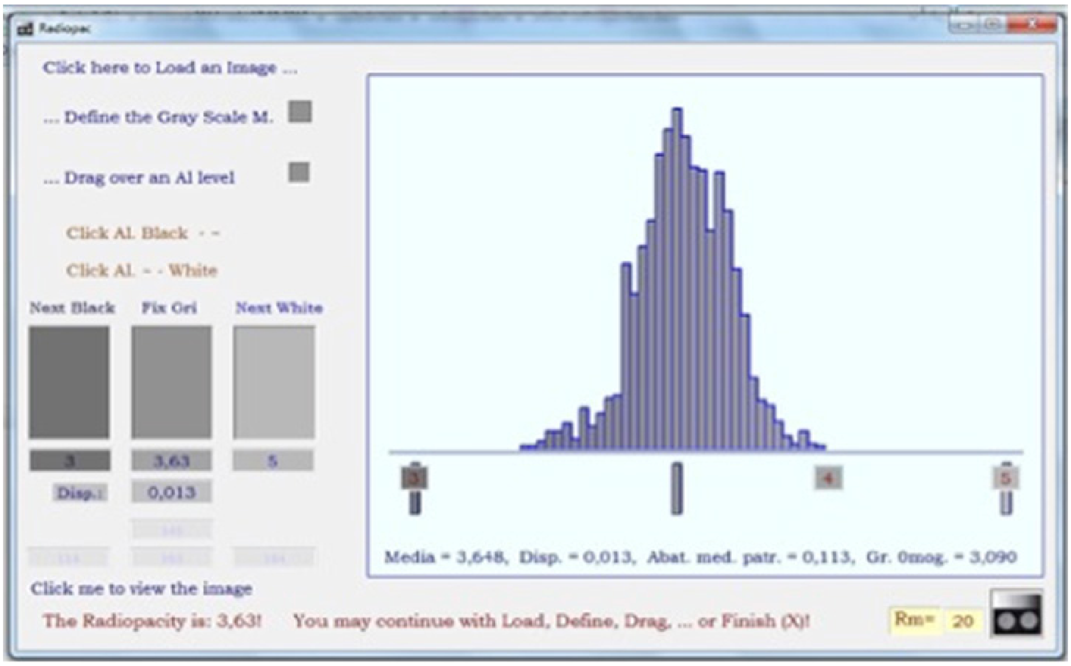

Figure 4. Determining the homogeneity using computer software.

Statistical interpretation of the results was performed using one-way ANOVA, and the significance level was set at p≤0.05.

Results

Table II shows the radiopacity of the two materials in the four quadrants (I, II, III, IV) of the disc to be sealed. Radiopacity is expressed in terms of equivalent aluminum thicknesses (in millimeters), higher values accounting for higher radiopacity.

The average radiopacity of Total Fill BC sealer is 4±0.15, and that of the experimental material is 3.77±0.27. Although there were differences between the values determined for the two materials, they were not statistically significant (p>0.05).

Table II. The radiopacity of the two materials.

Sealer/ Quadrant	Total Fill I	Total Fill II	Total Fill III	Total Fill IV	Exp. mat. I	Exp. mat. II	Exp. mat. III	Exp. mat. IV
Sample 1	3.89	3.63	3.94	3.91	3.42	3.23	3.36	3.29
Sample 2	4.01	3.98	3.96	4.08	3.62	3.73	3.64	3.81
Sample 3	4.15	4.21	4.18	4.32	3.84	3.92	3.82	4.02
Sample 4	3.97	3.86	4.03	3.99	3.11	3.75	3.88	3.95
Sample 5	4.08	3.97	4.15	4.11	3.79	3.66	3.92	3.96

Discussion

The tightness of root fillings is imperative to maintain the sterile environment obtained from the mechanical and antiseptic treatment of the root canal [21]. The type of filling material may influence the radiographic images of root canal treatment [22].

Radiopacity is a desirable quality of root canal sealers as it allows the estimation of the length, width and the shortcomings that may occur during treatment [22,23]. Using a material with a very high radiopacity may give the false impression of compact filling, despite the presence of voids in its mass. Conversely, a low radiopacity of the material can be interpreted as its absence in areas where it is found in a very small amount.

Conventional radiography and optical densitometry have been usually used in the literature to evaluate the radiopacity of filling materials [16]. The indirect method has also been used in some studies, converting existing radiographs into digital images [24,25]. Meanwhile, the use of digital radiographs has become more popular, as they save time and increase image quality [25].

In this study, digital radiographic images were evaluated using computer software for analyzing and comparing the images obtained. By using digital radiography, it was not necessary to convert conventional film radiographic images or to perform image calibration, since both samples and standards were positioned simultaneously on the intraoral sensor. ISO standards do not mention the use of the indirect or direct method for assessing the radiopacity of dental materials, so this should be taken into account in the future by the International Organization for Standardization [26]. Rasimick et al. [27] have established that the radiographic technique influences radiopacity values of filling materials. Materials containing barium and bismuth may have different radiopacity when using phosphor plates. There can also be differences in aluminum step wedge alloy, shutter speed, focal length, kVp, mAs, all of which influence radiopacity measurements.

According to international standards, the radiopacity of root canal sealing materials should be ≥3 mm equivalent aluminium thickness, although a few filling materials on the market do not comply with this requirement [28]. Some authors have suggested that a value of at least 4 mm equivalent aluminum thickness would be more appropriate [27]. Based on the results obtained in this study, Total Fill presented a radiopacity close in value to that of the experimental material and similar to another bioceramic sealer - Endosequence BC which, according to a study by Candeiro et al. [29], showed a radiopacity of 3.84 mm equivalent aluminium thickness. Considering that the experimental material studied in this paper is a resin-based material, the incorporation of radiopaque agents can easily modify radiopacity, but an increased radiopacity might hide filling mass imperfections, especially when the sealer is used in combination with gutta-percha.

Aoyagi et al. [30] have reported that radiopacity increased with the increase in opaque agent content, as well as with the increase in the atomic number of the element. Chang-Kyu Kim et al. [31] have assumed that the increase in radiopacity of a root canal filling material entails the increase in cytotoxicity, but they haven't detected any correlation between these two factors. This means that the radiopaque agent is not the only one that is cytotoxic, but other components of the sealers also contribute to its cytotoxicity.

Conclusions

The radiopacity of the materials in this study varied, but the differences were not statistically validated. All values determined were higher than 3 mm aluminium thickness and therefore they have all complied with ISO standards.

References

1. Sjögren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long term results of endodontic treatment. J Endod. 1990;16:498-504.
2. Ricucci D, Lin LM, Spångberg LS. Wound healing of apical tissues after root canal therapy: a long-term clinical, radiographic, and histopathologic observation study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;108:609-621.
3. Bodrumlu E, Sumer AP, Gungor K. Radiopacity of a new root canal sealer, Epiphany. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104:58-61.
4. Nunes VH, Silva RG, Alfredo E, Sousa-Neto MD, Silva-Sousa YT. Adhesion of Epiphany and AH Plus sealers to human root dentin treated with different solutions. Braz Dent J. 2008;19:46-50.
5. Ørstavik D. Materials used for root canal obturation: technical, biological and clinical testing. Endod Topics. 2005;12(6):25-38.
6. Ørstavik D, Nordahl I, Tibballs JE. Dimensional change

following setting of root canal sealer materials. Dent Mater. 2001;17:512-519.
7. Onay EO, Ungor M, Ozdemir BH. In vivo evaluation of the biocompatibility of a new resin-based obturation system. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;104:e60-e66.
8. Scarparo RK, Grecca FS, Fachim EV. Analysis of tissue reactions to methacrylate resin-based, epoxy resin-based, and zinc oxide-eugenol endodontic sealers. J Endod. 2009;35:229-232.
9. Carvalho-Junior JR, Correr-Sobrinho L, Correr AB, Sinhoreti MA, Consani S, Sousa-Neto MD. Solubility and dimensional change after setting of root canal sealers: a proposal for smaller dimensions of test samples. J Endod. 2007;33:1110-1116.
10. Resende LM, Rached-Junior FJ, Versiani MA, Souza-Gabriel AE, Miranda CE, Silva-Sousa YT, et al. A comparative study of physicochemical properties of AH Plus, Epiphany, and Epiphany SE root canal sealers. Int Endod J. 2009;42:785-793.
11. Versiani MA, Carvalho-Júnior JR, Padilha MI, Lacey S, Pascon EA, Sousa-Neto MD. A comparative study of physicochemical properties of AH Plus and Epiphany root canal sealants. Int Endod J. 2006;39:464-471.
12. Imai Y, Komabayashi T. Properties of a new injectable type of root canal filling resin with adhesiveness to dentin. J Endod. 2003;29:20-23.
13. Laghios CD, Benson BW, Gutmann JL, Cutler CW. Comparative radiopacity of tetracalcium phosphate and other root-end filling materials. Int Endod J. 2000;33:311-315.
14. Higginbotham TL. A comparative study of physical properties of five commonly used root canal sealers. Oral Surg Oral Med Oral Pathol. 1967;24:89-101.
15. Eliasson ST, Haasken B. Radiopacity of impression materials. Oral Surg Oral Med Oral Pathol. 1979;47:485-491.
16. Beyer-Olsen EM, Orstavik D. Radiopacity of root canal sealers. Oral Surg Oral Med Oral Pathol. 1981;51:320-328.
17. American Dental Association. ANSI/ADA Specification no. 57 - Endodontic Sealing Material. Chicago: ADA; 2000.
18. Chisnoiu R, Moldovan M, Păstrav O, Delean A, Prodan D, Boboia S, et al. Radiopacity Measurements of Three Endodontic Sealers Using Digital X-Rays. AIP Conf Proc. 2015, 700(1):1-5.
19. Akerboom HB, Kreulen CM, van Amerongen WE, Mol A. Radiopacity of posterior composite resins, composite resin luting cements, and glass ionomer lining cements. J Prosthet Dent. 1993;70:351-355.
20. Prejmerean V, Silaghi-Dumitrescu L, Prodan D, Prejmerean C, Moldovan M. Study of some Dental Biomaterials Properties using an Original Software Application. Key Engineering Materials. 2014;587:121-127.
21. Peters LB, Wesselink PR, Moorer WR. The fate and the role of bacteria left in root dentinal tubules. Int Endod J. 1995;28:95-99.
22. Baksi Akdeniz BG, Eyüboğlu TF, Şen BH, Erdilek N. The effect of three different sealers on the radiopacity of root fillings in simulated canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103:138-141.
23. van der Sluis LW, Wu MK, Wesselink PR. An evaluation of the quality of root fillings in mandibular incisors and maxillary and mandibular canines using different methodologies. J Dent. 2005;33:683-688.
24. Gambarini G, Testarelli L, Pongione G, Gerosa R, Gagliani M. Radiographic and rheological properties of a new endodontic sealer. Aust Endod J. 2006;32:31-34.
25. Tagger M, Katz A. Radiopacity of endodontic sealers: development of a new method for direct measurement. J Endod. 2003;29:751-758.
26. Sabbagh J, Vreven J, Leloup G. Radiopacity of resin-based materials measured in film radiographs and storage phosphor plate (Digora). Oper Dent. 2004;29:677-684.
27. Rasimick BJ, Shah RP, Musikant BL, Deutsch AS. Radiopacity of endodontic materials on film and a digital sensor. J Endod. 2007;33:1098-1104.
28. Shipper G, Teixeira FB, Arnold RR, Trope M. Periapical inflammation after coronal microbial inoculation of dog roots filled with gutta-percha or resilon. J Endod. 2005;31:91-96.
29. Candeiro GT, Correia FC, Duarte MA, Ribeiro-Siqueira DC, Gavini G. Evaluation of radiopacity, pH, release of calcium ions, and flow of a bioceramic root canal sealer. J Endod. 2012;38(6):842-845.
30. Aoyagi Y, Takahashi H, Iwasaki N, Honda E, Kurabayashi T. Radiopacity of experimental composite resins containing radiopaque materials. Dent Mater J. 2005;24:315-320.
31. Kim CK, Ryu HW, Chang HS, Lee BD, Min KS, Hong CU. Evaluation of the radiopacity and cytotoxicity of resinous root canal sealers. J Korean Acad Conserv Dent. 2007;32(5):419-425.