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Radiopacity of glass fiber dowels and self-adhesive resinous cements in radiography and digital systems

Radiopacidade de pinos de fibra de vidro e cimentos resinosos autoadesivos em radiografia e sistemas digitais

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Abstract

The aim of this study was to evaluate the radiopacity of three self-adhesive resinous cements and four glass fiber dowels, exposed on film and two digital imaging systems (CCD - IOX and CR - Kodak). Test specimens were made of each cement (Rely X U100 – 3M-ESPE, seT – SDI, Biscem – Bisco) and were exposed together with the dowels (FRC Postec Plus – Ivoclar, Transluma – Bisco, White Post DC - FGM, Exacto – Angelus) and an aluminum stepwedge. The resinous cement seT presented the highest radiopacity value, whereas the cement Biscem had the lowest value. The fiber dowel FRC Postec Plus obtained the highest radiopacity values, irrespective of the system, followed by the White Post DC.

Keywords: radiopacity; resinous cement; glass fiber dowles

Resumo

O objetivo deste estudo foi avaliar a radiopacidade de três cimentos resinosos autoadesivos e quatro pinos de fibra de vidro, expostos em filme e em dois sistemas de imagem digital (CCD – IOX e CR – oda). Foram confeccionados corpos de prova de cada cimento (Rely X U100 – SDI, Biscem – Bisco) e expostos juntamente com os tarugos (FRC Postec Plus – Ivoclar, Transluma – Bisco, White Post DC – FGM, Exacto – Angelus) e uma escada de alumínio. O cimento resinoso seT apresentou o maior valor de radiopacidade, enquanto o cimento Biscem apresentou o menor valor. O pino de fibra FRC Postec Plus obteve os maiores valores de radiopacidade, independente do sistema, seguido pelo White Post DC.

Palavras-chave: radiopacidade; cimentos resinosos; pinos de fibra de vidro

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1 Introduction

Endodontically treated teeth undergo great loss of tooth structure. During the restorative procedure, whether it is a direct or a prosthetic restoration, it is necessary to use of a retainer. The association of dowels, resinous cements and filling materials result in an artificial dentin, promoting an adequate substrate for receiving an indirect restoration.[15]

Gaps, marginal defects and secondary caries are better detected with the radiopacity of the material is similar to that of enamel, or equal to or greater than the same aluminum thickness. This metal was chosen as reference because it has radiopacity; that is, a linear absorption coefficient similar to that of dentin. [3,7,10,11]

In order to evaluate the correct insertion and complete filling during cementation, evaluate treatment in the long term, as well as the need for endodontic re-treatment in teeth treated with intracanal dowels, radiographic exams have to be performed. To make this possible, it is necessary for the material to have sufficient radiopacity to be visible on radiographs. Conventional quartz and glass fiber dowels are not easily detected in radiographs, as opposed to what happens with ceramic and metal dowels.[7,13, 15]

The composition of the materials greatly influences radiopacity. The content in percentage of weight and volume, and the chemical composition of the load particles are determinants of this property. Materials with over 20% of radiopaque oxides, such as vitreous loads of barium, strontium and zirconium present higher radiopacity values.[8, 9,10]

The use of digital systems favors the reduction in the dose of radiation, diminishes the problems with processing films, and enables higher quality images to be obtained, due to the possibility of manipulation, in addition to allowing a strict evaluation of radiodensity.[10,18]

The aim of this study was to evaluate the radiopacity of glass fiber dowels and self-adhesive resinous cements in radiographs and in two digital systems (CCD and CR) in accordance with the ANSI/ADA and ISO 4049 standards. [3, 11]

2 Material and methods

A To conduct this study, three self-adhesive resinous cements and four glass fiber dowels were used (Table 1).

Table 1 – Resinous Cements and Glass Fiber Dowels

	Commercial brand	Composition	Manufacturer	Lot
Cements	Rely-X U100	Modified Methacrylate Monomer and 70% inorganic load (calcium ions, aluminum, strontium and fluoride)	3M-ESPE – Minnesota - USA	351380
	seT	BIS-GMA, UDMA and BIS-EMA, Load: Zirconium and Silica, 47% by volume and 68% by weight.	SDI - Victoria – Austrália	S0810072
	BisCem	Bis (Hydroxyethyl methacrylate) and tetraethylene glycol dimethacrylate Load: Dental glass (<85%)	Bisco Inc – Schaumburg - USA	0800010406
Dowels	FRC Postec	Dimethacrylate (21%), ytterbium fluoride (9%), glass fiber (70%) and catalyzers (0.5%)	Ivoclar/Vivadent – Liechtenstein	L57347
	White Post DC	Glass fiber, epoxy resin, radiopaque component, catalyzer, inorganic load	FGM – Brazil	071008
	Exacto	Glass fiber (87%), epoxy resin (13%) and stainless steel	Ângelus, Brazil	8192
	TransLuma Post	Glass fiber (<75%), epoxy resin (<30%), inorganic loads (<10%)	Bisco Inc – Schaumburg – USA	0800011007

Ten test specimens were prepared with each cement, and the five that presented the most homogeneous surface seen in the radiographic images were selected. Tin matrices were made, in accordance with the requirements established in Rule 27 of the American Dental Association (1993), with an internal diameter of 10mm and thickness of 2mm.[3]

The matrices were isolated and supported on a previously isolated glass plate. The materials were manipulated in accordance with the manufacturers' specifications, and were inserted in the matrix with the aid of its own applicator, with the exception of Rely X U100 cement, for which a Centrix syringe was used. After the matrix was filled, a glass slide was used to put pressure on the cement, so that it would completely adapt to the slide, preventing the formation of bubbles. After this the cement was polymerized with a Radii Plus (SDI) appliance, in accordance with the manufacturer's specifications. On conclusion of polymerization, the test specimens were removed from the matrices, their thickness gauged with a digital pachymeter, and the surface adjusted with Sof-lex abrasive disks (3M-ESPE).

The dowels were radiographed placed on the film in the longitudinal direction. The experimental arrangement for the Insight (Kodak) radiographic film and the CR (Kodak) digital system of the cements was composed of a test specimen of each material and an aluminum stepwedge, while for the CCD (IOX) digital system, it was composed of two test specimens of each material and a stepwedge, and one test specimen and a stepwedge. For the dowels, the arrangement was composed of one dowel from each manufacturer and the aluminum stepwedge, both for the film and the digital systems.

An X Spectro 70X Electronic (Dabi Atlante – Brazil) x-ray appliance was used, with 70kVp and 8mA, maintained at a focus-film distance of 40 cm for all the exposures.

Exposure time was 0.4s for the film and CR system, and 0.2s for the CCD System, established by means of choice by 3 examiners with experience in the area, with the exactness and reproducibility of the x-ray appliance being confirmed by an RMI 242 (Gammex) appliance.

The films were processed by the temperature/time method, with the times being 2 min for the revealer, 30s for the intermediate bath, 5 min for the fixer and 5min for the final bath. After the radiographic processing had been performed, the optical densities of the conventional films were measured, using an M.R.A., model 07-443 photodensitometer, with a 1mm opening. The readout was taken at the base of the film (LB), and after this, the optical density measurements (OD) of the test specimens of the cements, dowels and stepwedge. In the cement test specimens, 5 random measurements were made to obtain a mean optical density, and in the dowels, two readouts were made in the most cervical portion as it is the most cylindrical part of the dowel. Having the LB and OD measurements, the net optical density value (NOD) of the materials and of the degrees was calculated by subtracting LB from OD.

In the digital images, the gray tone values were gauged by means of Photoshop CS4 Software (Adobe). Readouts in the digital systems were performed in the same way as in the conventional film, with the exception of the readout at the base of the film.

For each exposure a graph of the readouts versus mmAl was made in the Microsoft Excel 2003 (Microsoft) software, thus obtaining the radiopacity curve of the stepwedge degrees, in order to obtain, by means of an equation, the radiopacity value of the materials in equivalent mmAl. To construct the curves, a mathematical approximation was made by means of an exponential tendency curve, with the object of this curve passing through the largest possible number of points, thus obtaining a value of R^2 closest to 1.

In the intraoral digital systems, the depth of the bit is 8 bits, which is equivalent to 256 possible gray tones, the darkest usually being defined by zero and the lightest by 255. In opposition to the density measurements in films, in which the darkest areas record the highest values, in digital images they record the lowest. In order to obtain the same type of curve, we inverted the N values of white (inverse of gray), transforming them into white diminishing the value of the reading of 255.

3 Results

Table 2 presents the mean and standard deviation of radiopacity, according to the types of image system, cement and post. The result of the two-way ANOVA test (with two classification factors) indicated that there was significant interaction between system and cement ($p = 0.040$) and between system and post ($p<0.001$).

Table 2 - Mean ± Standard Deviation of radiopacity, according to the types of Image, Cement and Post system

System			
Cement	**Film**	**CCD**	**CR**
Rely-X U100	3.16 ± 0.36*	4.98 ± 0.28*	3.73 ± 0.08*
seT	3.30 ± 0.54*	5.03 ± 0.10*	3.92 ± 0.31*
Biscem	2.18 ± 0.12*	3.83 ± 0.15*	3.31 ± 0.15*
Dowels			
Transluma	1,24 ± 0.11**	0.83 ± 0.08**	1.83 ± 0.03**
WhitePost	4.66 ± 0.58**	3.6 ± 0.51**	3.37 ± 0.27**
Exacto	3.22 ± 0.18**	1.61 ± 0.05**	2.11 ± 0.01**
FRC Postec Plus	5.63 ± 0.31**	5.06 ± 0.23**	4.9 ± 0.10**

Table 3 shows that after controlling the image system, it was found that the mean radiopacity varied according to the type of cement. The results of the multiple comparison tests showed that there was no statistically significant difference between the cements R and S in any of the three systems, but cement B presented a significantly higher mean radiopacity than cements R and S, in the three systems.

Table 3 - Comparisons of radiopacity means, according to the type of cement, controlling the type of image system

System	Cement	Mean difference	p^*
Film	Rely-X U100 vs seT	3.16 - 3.30 = -0.14	0.417
	Rely-X U100 vs Biscem	3.16 - 2.18 = 0.98	< 0.001

	seT vs Biscem	3.30 - 2.18 = 1.12	< 0.001
CCD	Rely-X U100 vs seT	4.98 - 5.03 = -0.05	0.774
	Rely-X U100 vs Biscem	4.98 - 3.83 = 1.15	< 0.001
	seT vs Biscem	5.03 - 3.83 = 1.20	< 0.001
CR	Rely-X U100 vs seT	3.73 - 3.92 = -0.19	0.284
	Rely-X U100 vs Biscem	3.73 - 3.31 = 0.42	0.037
	seT vs Biscem	3.92 - 3.31 = 0.61	0.003

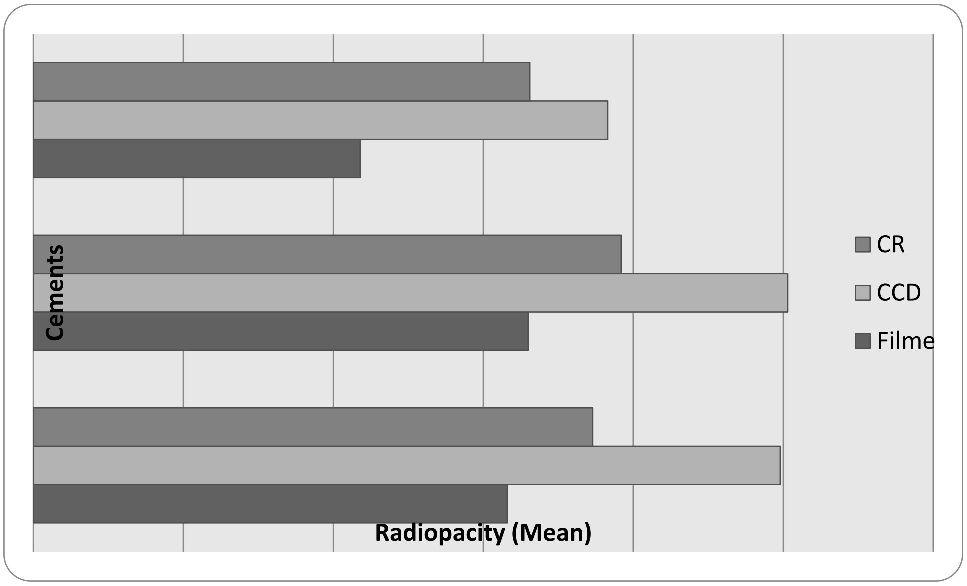
Table 4 shows that after controlling the image system, it was found that the mean radiopacity varied according to the type of post. The results of multiple comparison tests showed that there was statistically significant difference between the posts in any of the three imaging systems, with the exception of posts T and E, which presented no significant difference with system CR (p = 0.299).

Table 4 - Comparisons of radiopacity means, according to the type of post, controlling the type of image system

System	Dowel	Mean difference	p*
Film	Transluma vs WhitePos	1.24 - 4.66 = - 3.42	< 0.001
	Transluma vs Exacto	1.24 - 3.22 = - 1.98	< 0.001
	Transluma vs FRC Postec Plus	1.24 - 5.63 = - 4.39	< 0.001
	WhitePost vs Exacto	4.66 - 3.22 = 1.44	< 0.001
	WhitePost vs FRC Postec Plus	4.66 - 5.63 = - 0.97	< 0.001
	Exacto vs FRC Postec Plus	3.22 - 5.63 = - 2.41	< 0.001
CCD	Transluma vs WhitePos	0.83 - 3.60 = - 2.77	< 0.001
	Transluma vs Exacto	0.83 - 1.61 = - 0.78	0.002
	Transluma vs FRC Postec Plus	0.83 - 5.06 = - 4.23	< 0.001
	WhitePost vs Exacto	3.60 - 1.61 = 1.99	< 0.001
	WhitePost vs FRC Postec Plus	3.60 - 5.06 = - 1.46	< 0.001

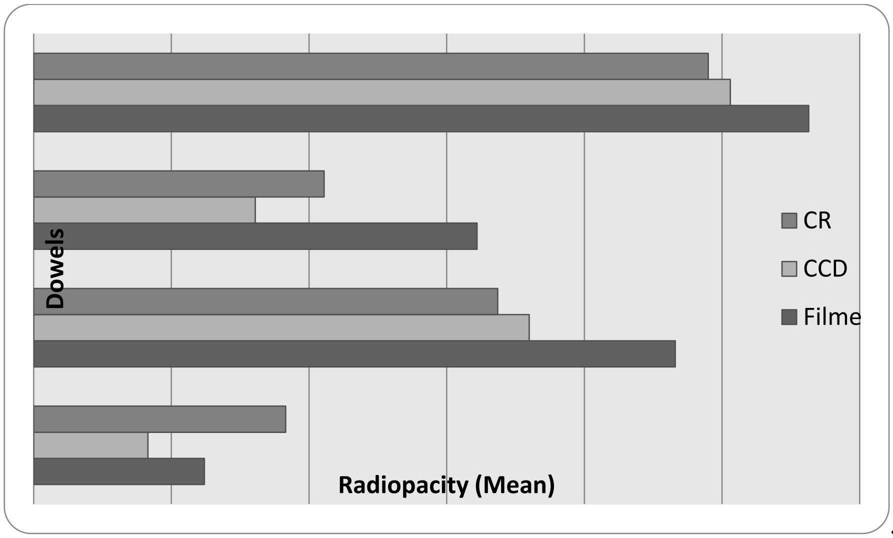
	Exacto vs FRC Postec Plus	1.61 - 5.06 = -3.45	< 0.001
CR	Transluma vs WhitePos	1.83 - 3.37 = -1.54	< 0.001
	Transluma vs Exacto	1.83 - 2.11 = - 0.28	0.229
	Transluma vs FRC Postec Plus	1.83 - 4.90 = -3.07	< 0.001
	WhitePost vs Exacto	3.37 - 2.11 = 1.26	< 0.001
	WhitePost vs FRC Postec Plus	3.37 - 4.90 = -1.53	< 0.001
	Exacto vs FRC Postec Plus	2.11 - 4.90 = - 2.79	< 0.001

Graph 1 shows that after controlling the type of cement, it was found that the mean radiopacity varied according to the type of imaging system. The results of the multiple comparison tests showed that the mean radiopacity with film was significantly lower in comparison with CCD and CR, for any type of cement. On the other hand, the mean radiopacity with CCD was also significantly higher in comparison with CR for any type of cement.



Graph 1 - Radiopacity means, according to the type of imaging system, when controlling the type of cement

Graph 2 shows that after controlling the type of post, the mean radiopacity also varied according to the type of imaging system. The results of the multiple comparison tests showed that no statistically significant differences were found only between Film and CCD with post T (p = 0.072) and between CCD and CR, with post F (p = 0.477).



Graph 2 - Radiopacity means, according to the type of imaging system, when controlling the type of post

4 Discussion

A restorative material must have sufficient radiopacity to enable it to be differentiated from dental structures, thus facilitating diagnosis.[1] For evaluating the property of radiopacity, studies are based on international standards, such as ISO 4049:2000(E) [2,,4,12,14] and ANSI/ADA specification 27 (1993).[11]

When X-rays attain the material, they are absorbed by the atoms or dispersed without loss of energy. The interaction of X-rays with the material is directly proportional to its atomic number or to the electric density of the X-rays. In addition to the atomic number of materials, their physical structure and thickness also influence radiopacity. [9]

Resinous cements are composed of inorganic particles dispersed throughout the organic matrix. The radiopacity of resins depends on the type, quantity and size of the load particles of which they are composed; that is to say, glass particles that contain atoms of heavy metals, with high atomic numbers (AN) such as barium (AN=56), zirconium (AN=40), ytterbium (AN=70), strontium (AN=38) and zinc (AN=30), since the organic matrix is substantially radiolucent.[5] Materials that have a higher radiopacity than enamel are composed of loads with over 20% of barium oxide, strontium or zirconium. [16,17]

The higher radiopacity values presented by cements S and R in comparison with cement B, are directly related to the load particles of which they are composed.[16,17] Cement S has loads composed of zirconium and silicon oxides (AN=14), being 47% by volume and 68% by weight, whereas cement R has loads in its composition, composed of calcium ions (AN=20), aluminum (AN=13), strontium and fluoride (AN=9) ions.

Glass fibers have a behavior with respect to radiopacity, similar to that of the resinous matrix; that is to say, they are inherently radiolucent materials.[8] However, differently from the resinous cements that have over 40% by volume or weight of loads in their composition, the posts have a load of less than 10%, or even no load whatever, as is the case with Post E, which is composed of glass fiber, epoxy resin and a fillet of stainless steel.

Post F was the one that presented the highest radiopacity value, irrespective of the system analyzed, certainly due to the ytterbium oxides present in its composition, followed by post W. Post T was the one that obtained the lowest radiopacity values in all the imaging systems. The stainless steel fillet present in post E did not favor the radiopacity of this material, certainly because it is around 0.2mm thick, which does not influence the readout, since it is performed by area, in spite of this metal alloy presenting high radiopacity values. [8] This metal could favor its visualization in a radiographic image.

The digital recording of intraoral images has advantages when compared with conventional film, such as questions pertaining to environmental issues and image processing, and in particular, diminishing the dose of radiation.[12] The new receivers are classified into CCD (Charge-Coupled Device) and phosphorous stimulation plate, which differ in some aspects, such as in the dynamic scales. [19]

For the analysis of resinous cements the digital systems showed a greater sensitivity and were statistically superior to that of film, corroborating the work of Bóscolo *et al* (2001). [6] In analysis of the posts, it was observed that film presented greater sensitivity, a fact also found in the work of WOOLHISER *et al* (2005)[20], when they analyzed the accuracy of determining endodontic length, in which no statistical difference was observed between film and digital systems.

When analyzing the cements, the CCD system showed superior results to those of CR, probably because of having a larger dynamic scale and contrast, and both favored higher radiopacity values than film. When evaluating the posts, with the exception of Post T, film demonstrated greater sensitivity than the CCD and CR systems.

5 Conclusion

It could be concluded that all the cements, irrespective of the system analyzed, had higher radiopacity than that stipulated by the ANSI/ADA[4] and ISO 4049 standards.[11] With regard to posts, it was observed that Post T did not attain the minimum radiopacity values demanded by the standards in all the systems, while Post E obtained a lower radiopacity value than that demanded when analyzed in the CCD system.

Referências

1. ABOU-TABL, ZM, *et al*. Radiopacity of composite restorative materials. **British Dental Journal**, [*S. l.*], v. 147, p. 187-8, 1979.

2. AKERBOOM HB, *et al*. Radiopacity of posterior composite resins, composite resin luting cements, and glass ionomer lining cements. **The Journal of Prosthetic Dentistry**, [*S. l.*], v. 70, p.351-5, 1993.

3. American National Standard/American Dental Association Specification No. 27 Resin-based filling materials. Chicago, IL: American Dental Association Council on Dental Materials and Equipment; 1993.

4. ATTAR N, *et al*. Flow, strength, stiffness and radiopacity of flowable resin composites. **Journal de L'Association dentaire canadienne**, [*S. l.*], v. 69, p. 516-521, 2003.

5. BEYER-OLSEN, EM, *et al*. Radiopacity of root canal sealers. **Oral Surgery Oral Medicine and Oral Pathology**, [*S. l.*], v. 51, p. 320-328, 1981.

6. BÓSCOLO, FN, *et al*. Clinical study of the sensitivity and dynamic range of three digital systems, E-speed film and digitized film. **Brazilian Dental Journal**, [*S. l.*], v. 12, p. 191-195, 2001.

7. COOK, WD. An investigation of the radiopacity of composite restorative materials. **Australian Dental Journal**, [*S. l.*], v. 26, p. 105-112, 1981.

8. FINGER WJ, *et al*. Radiopacity of fiber-reinforced resin posts. **American Journal of Dentistry**, [*S. l.*], v. 15, p. 81-4, 2002.

9. FONSECA RB, *et al*. Radiodensity of base, liner and luting dental materials. **Clinical Oral Investigations**, v. 10, p. 114-8, 2006.

10. GOSHIMA, T *et al*. Optimum radiopacity of composite inlay materials and cements. **Oral Surgery Oral Medicine and Oral Pathology**, [*S. l.*], v. 72, p. 257-260, 1991.

11. ISO 4049 Polymer-based filling, restorative and luting materials. Geneva, Switzerland: International Organization for Standardization; 2000.

12. NIELSEN, LL, *et al*. Radiographic detection of cavitation in approximal surfaces of primary teeth using a digital storage phosphor system and conventional film, and the relationship between cavitation and radiographic lesion depth: an in vitro study. **International Journal of Paediatric Dentistry**, [*S. l.*], v. 6, p. 167-72, 1996.

13. Rasimick BJ, *et al*. Measuring the radiopacity of luting cements, dowels, and core build-up materials with a digital radiography system using a CCD sensor. **Journal of Prosthodontics**, [*S. l.*], v. 16, p. 357-64, 2007.

14. SABBAGH J, *et al*. Radiopacity of resin-based materials measured in film radiographs and storage phosphor plate (Digora). **Operative Dentistry**, [*S. l.*], v. 29, p. 677-84, 2004.

15. SOARES, CJ *et al*. Radiodensity evaluation of seven root post systems. **American Journal of Dentistry**, [*S. l.*], v. 18, p. 57-60, 2005.

16. TOYOOKA H, *et al*. Radiopacity of 12 visible-ligth-cured dental composite resins. **Journal of Oral Rehabilitation**, [*S. l.*], v. 20, p. 615-22, 1993.

17. VAN DIJKEN JWV, *et al*. An evaluation of the radiopacity of composite restorative materials used in Class I and Class II cavities. **Acta Odontologica Scandinavica**, [*S. l.*], v. 47, p. 401-407, 1989.

18. WAKOH, M, *et al*. Digital imaging modalities for dental practice. **The Bulletin of Tokyo Dent College**, [*S. l.*], v. 42, p. 1-14, 2001

19. WENZEL, A, *et al*. Influence of spatial resolution and bit depth on detection of small caries lesions with digital receptors. **Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics**, [*S. l.*], v. 103, p. 418-22, 2007.

20. WOOLHISER, GA, *et al*. Accuracy of film-based, digital, and enhanced digital images for endodontic length determination. **Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics**, [*S. l.*], v. 99, p.499-504, 2005.

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