

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE ODONTOLOGIA

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AVALIAÇÃO DA RADIOPACIDADE DE MATERIAIS OBTURADORES
ENDODÔNTICOS UTILIZANDO UM NOVO MODELO EXPERIMENTAL *IN*
VITRO

Porto Alegre

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Trabalho de Conclusão de Curso apresentado ao Curso de Especialização em Endodontia da Faculdade de Odontologia da Universidade Federal do Rio Grande do Sul, como requisito para obtenção do título de especialista.

Orientadora: Prof. Dra. Fabiana Soares Grecca

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RESUMO

HOPPE, C.B. **Avaliação da radiopacidade de materiais obturadores endodônticos utilizando um novo modelo experimental *in vitro***. 2013. Trabalho de Conclusão de Curso (Especialização em Endodontia) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2013.

Objetivo: avaliar a radiopacidade dos materiais obturadores endodônticos usando um novo modelo experimental *in vitro*. **Metodologia:** Considerando a sobreposição dos tecidos e estruturas anatômicas, um bloco simulador de tecidos foi criado. Cones de Guta-percha e Resilon e tubos de polietileno preenchidos pelos cimentos Epiphany, AH Plus e Endofill (n=5 de cada material) foram posicionados dentro de um canal radicular de um dente que foi posicionado no simulador e radiografias foram realizadas. Além disso, cinco amostras de cada cimento foram preparadas em discos padronizados e radiografadas. Os filmes foram processados e digitalizados. As imagens digitais foram analisadas pelo programa Adobe Photoshop® e valores de escala de cinza (0 a 256 pixels) foram comparados usando os testes Wilcoxon e Mann-Whitney ($p < 0,05$) para avaliar os cones e ANOVA, Tukey, Testes t independente e dependente ($p < 0,05$) para avaliar os cimentos. **Resultados:** No simulador de tecidos, todos os cimentos apresentaram valores de cinza inferiores ao da metodologia dos discos padronizados. Ainda, AH Plus e Epiphany foram semelhantes, apresentando valores de cinza superiores ao Endofill. Os cones de Resilon se mostraram mais radiopacos do que a guta-percha e ambos mais do que a dentina. Nos discos padronizados, o AH Plus foi o cimento mais radiopaco, seguido pelo Epiphany e Endofill. **Conclusão:** Todos os materiais obturadores endodônticos apresentaram valores de cinza superiores à dentina, o que permite distingui-los do dente e das estruturas anatômicas em sua volta. A metodologia proposta pode ser usada para avaliação da radiopacidade.

Palavras-chave: endodontia, radiologia, radiopacidade, materiais obturadores.

ABSTRACT

HOPPE, C.B. **A new assessment methodology to evaluate the radiopacity of endodontic filling materials.** 2013. Trabalho de Conclusão de Curso (Especialização em Endodontia) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2013.

PURPOSE: evaluate the radiopacity of endodontic filling materials, using a new experimental *in vitro* model. **METHODS:** Considering the overlapping of tissues and anatomical structures, a tissue simulator block was created. Gutta-percha, Resilon cones and polyethylene tubes filled with Epiphany, AH Plus and EndoFill (n=5 of each material) were placed inside the root canal of a tooth positioned in the simulator and radiographed after set. Five sealer samples were prepared in standard discs and radiographed after set. Films were processed and digitized. The digital images were analyzed by Adobe Photoshop® software and grayscale values (0 to 256 pixels) were compared using Wilcoxon and Mann-Whitney tests ($P<0.05$) for the cones and ANOVA, Tukey, independent and dependent t tests ($P<0.05$) for the sealers. **RESULTS:** In the simulator, AH Plus and Epiphany behaved similarly, presenting higher gray value than Endofill. In standard discs, AH Plus was the most radiopaque followed by Epiphany and Endofill. Resilon presented higher radiopacity than gutta-percha and both were higher than dentin. **CONCLUSIONS:** All the endodontics filling materials presented higher gray values than dentin and allow distinguishing itself from the tooth and the surrounding structures. The methodology proposed can be used for the assessment of endodontic filling material radiopacity.

Keywords: endodontics; radiology; radiopacity; root canal filling materials.

1 INTRODUÇÃO

A obturação do canal radicular é o preenchimento, após o preparo químico-mecânico, do espaço anteriormente ocupado pela polpa, com o objetivo de selar o sistema de canais radiculares (LEONARDO, 2005).

Este preenchimento possui finalidades antimicrobianas e biológicas, podendo estimular o processo de reparo apical e conduzir, muitas vezes, ao fechamento biológico do forame radicular (GURGEL-FILHO *et al.*, 2003). Por isso, a obturação do canal radicular deve ser realizada com um material biocompatível, evitando a troca de fluidos tissulares do periápice com o interior do espaço endodôntico e mantendo o canal livre de micro-organismos (SUNDQVIST *et al.*, 1998).

A obturação do sistema de canais radiculares pode ser feita através da utilização de um material sólido associado a um cimento. Um componente sólido bastante utilizado é a guta-percha, sob a forma de cones padronizados, compostos basicamente por polímeros de guta-percha, ceras e resinas (componentes orgânicos) além de óxido de zinco e sulfato de bário (compostos inorgânicos) (GURGEL-FILHO *et al.*, 2003). A guta-percha é amplamente utilizada devido as suas boas propriedades físicas e biológicas (PASCON e SPANGBERG, 1990). No entanto, a falta de aderência às paredes do canal é uma desvantagem importante (GAMBARINI *et al.*, 2006). Dessa forma, uma satisfatória obturação não pode ser obtida sem o uso de um cimento. Assim, os cimentos devem possuir propriedades como escoamento, preenchimento dos espaços e discrepâncias entre os cones e a superfície do canal e canais laterais e acessórios inacessíveis aos cones padronizados além de aderir firmemente tanto à dentina quanto à guta-percha (CAICEDO e VON FRAUHOFFER, 1988; GAMBARINI *et al.*, 2006).

Um dos cimentos usados em associação à guta-percha, que possui propriedades importantes como obturação de longa duração, estabilidade dimensional (BOUILLAGUET *et al.*, 2008), auto-adesão e alta radiopacidade é o cimento à base de resina epóxica AH Plus (De Trey-Dentsply, Konstanz, Germany). Este contém óxido de zircônia e óxido de ferro como agentes que transferem radiopacidade. Outro cimento bem difundido é o Endofill, à base de óxido de zinco e eugenol, contém sulfato de bário, óxido de zinco e subcarbonato de bismuto

(GORDUYSUS E AVCU, 2009), cimento menos biocompatível para os tecidos periapicais que os cimentos resinosos (SILVA *et al.*, 2011).

Cones termoplásticos derivados de polímeros sintéticos - cones Resilon[®] - foram desenvolvidos mais recentemente, também sob a forma de cones padronizados, apresentando como vantagem adesividade aos cimentos à base de resina de metacrilato, com intuito de formar um monobloco (SHIPPER *et al.*, 2004; UREYEN KAYA *et al.*, 2008). Um desses cimentos é o Epiphany (Pentron Clinical Technologies, Wallingford, CT, USA), um cimento resinoso dual, composto por hidróxido de cálcio, sulfato de bário, cristais de bário e sílica (SHIPPER *et al.*, 2004; PAQUÉ e SIRTES, 2007; BOUILLAGUET *et al.*, 2008). De acordo com o fabricante, essa vantagem da adesão entre os materiais obturadores preveniria a penetração bacteriana, proporcionando uma vedação apical e coronal excelente.

Entre as propriedades físicas/químicas dos materiais obturadores, a radiopacidade é desejável por permitir aos clínicos distinguir o material obturador do dente e das estruturas adjacentes (BODRUMLU *et al.*, 2007). Além disso, a radiopacidade possibilita avaliar a qualidade da obturação, o tipo de material extravasado em casos de sobreobturaçã, a presença de espaços vazios ou a má condensação dos materiais obturadores. (BASKI AKDENIZ *et al.*, 2007).

Com o constante advento de novos materiais obturadores endodônticos, é importante que estes tenham suas propriedades avaliadas e comparadas com os materiais já disponíveis há mais tempo no mercado.

Higginbotham, em 1967, foi o primeiro pesquisador a publicar um estudo comparando a radiopacidade de vários cimentos endodônticos e cones de gutapercha usados para obturar canais radiculares. Eliasson e Haasken (1979) foram os primeiros a estabelecer um método padrão para mensurar a radiopacidade de materiais dentários com uma escala de alumínio (penetrômetro), permitindo a leitura das transformações de luzes transmitidas em uma equivalente densidade de alumínio. De acordo com a International Organization for Standardization a radiopacidade dos materiais obturadores de canais radiculares deve ser igual ou maior que 3 mm de alumínio.

Essa metodologia tradicional avalia os materiais obturadores endodônticos sem considerar a sobreposição dos tecidos e das estruturas anatômicas. A ausência do trabeculado ósseo e dos tecidos moles constitui um importante diferencial em

relação às situações clínicas quando a radiopacidade está sendo investigada, podendo alterar a percepção da radiopacidade dos materiais.

Devido a essas limitações, métodos alternativos têm sido propostos. O advento da digitalização de imagens permite o uso de programas específicos para se determinar valores de cinza através dos pixels da imagem. Ainda, visando a simulação das condições clínicas, Gegler e Fontanella (2008) desenvolveram um bloco simulador de tecidos que já foi usado com sucesso em estudos de diagnóstico de reabsorções radiculares apicais externas, entretanto, não havia sido utilizado para avaliar a radiopacidade de materiais obturadores.

A partir disso, objetivou-se avaliar a radiopacidade de três cimentos endodônticos (Endofill, AH Plus e Epiphany) e dos cones de guta-percha e Resilon utilizando um novo modelo experimental.

2 OBJETIVO

O objetivo deste estudo foi avaliar a radiopacidade de três cimentos endodônticos, um cimento à base de óxido de zinco e eugenol (Endofill- Dentsply HERO Indústria e Comércio Ltda, Petrópolis, RJ, Brazil) e dois cimentos resinosos (AH Plus - De Trey - Dentsply, Konstanz, Germany e Epiphany - Pentron Clinical Technologies, Wallingford, CT, USA), e cones de guta-percha e Resilon usando um novo modelo experimental *in vitro*.

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Revista Odonto Ciência (Journal of Dental Science) – Editorial decision

Dear Dr. Carolina Bender Hoppe,

We are pleased to inform you that your revised manuscript entitled "A new assessment methodology to evaluate the radiopacity of endodontic filling materials" was accepted for publication in the Revista Odonto Ciência (Journal of Dental Science).

After editing the page proofs will be sent to your e-mail address for final approval before printing. The online issue will allow the download of full-text articles in pdf file, and a complimentary printed journal will be mailed to you.

We thank you again for considering our journal to publish your work.

Sincerely,

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A new assessment methodology to evaluate the radiopacity of endodontic filling materials

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ABSTRACT

PURPOSE: evaluate the radiopacity of endodontic filling materials, using a new experimental *in vitro* model. **METHODS:** Considering the overlapping of tissues and anatomical structures, a tissue simulator block was created. Gutta-percha, Resilon cones and polyethylene tubes filled with Epiphany, AH Plus and EndoFill (n=5 of each material) were placed inside the root canal of a tooth positioned in the simulator and radiographed after set. Five sealer samples were prepared in standard discs and radiographed after set. Films were processed and digitized. The digital images were analyzed by Adobe Photoshop[®] software and grayscale values (0 to 256 pixels) were compared using Wilcoxon and Mann-Whitney tests ($P<0.05$) for the cones and ANOVA, Tukey, independent and dependent t tests ($P< 0.05$) for the sealers. **RESULTS:** In the simulator, AH Plus and Epiphany behaved similarly, presenting higher gray value than Endofill. In standard discs, AH Plus was the most radiopaque followed by Epiphany and Endofill. Resilon presented higher radiopacity than gutta-percha and both were higher than dentin. **CONCLUSIONS:** All the endodontics filling materials presented higher gray values than dentin and allow distinguishing itself from the tooth and the surrounding structures. The methodology proposed can be used for the assessment of endodontic filling material radiopacity.

Keywords: endodontics; radiology; radiopacity; root canal filling materials.

INTRODUCTION

Among other physical/chemical properties, an ideal root canal sealing material should present sufficient radiopacity to allow radiographic assessment and to distinguish itself from the tooth and the surrounding structures. Previous studies indicated that gutta-percha cones and most endodontic sealers exceeded the minimal radiopacity requirement (1-5). However, the absence of an ideal root filling material has stimulated the development of new products that must have their radiopacity evaluated.

Elíasson and Haasken (6) were the first to establish a standardized method of radiopacity measurements for dental. This traditional methodology evaluates endodontic filling materials without considering the overlapping of tissues and anatomical structures. The absence of bony trabeculae and soft tissues constitutes an important differential in relation to clinical situations when the radiopacity is being investigated, it may alter the perception of the radiopacity of dental materials (7).

Due to these limitations, alternative methods must be suggested. The advent of image digitalization allows the use of specific software to determine the gray pixel values (8). Besides, aiming at simulating clinical conditions, Gegler and Fontanella (7) developed a "tissue simulator block". This experimental model has already been successfully used in studies on diagnosis of external apical root resorption, but it has not been used to evaluate the radiopacity of endodontic materials (7, 9)

Therefore, the aim of this study was to assess the radiopacity of three endodontic sealers, a zinc oxide and eugenol-based sealer (Endofill) and two

resin-based sealers (AH Plus and Epiphany), and gutta-percha and Resilon cones using a new experimental *in vitro* model.

MATERIAL AND METHODS

The present study was approved by the Ethics Committee of the Federal University of Rio Grande do Sul (Brazil).

Aiming at reproducing a clinical situation as precisely as possible, a tissue simulator block was created (7). The maxilla of a human skull was used, and the separation of its anterior region was obtained using a diamond double-faced disc (KG Sorensen, Barueri, SP, Brazil). The part obtained was divided, by sagittal osteotomy, into two segments, the buccal one and the palatal one.

The segments were fixed with wax (Wilson, São Paulo, SP, Brazil) in a plastic container (length=6 cm, width=2.5 cm, depth=3.5 cm). Distances of 1 cm were established between the external surfaces of the buccal and palatal segments and the container's walls, being this space latter filled with pored acrylic self-curing (Artigos Odontológicos Clássico, São Paulo, SP, Brazil) that would simulate the soft tissues.

A distance of 0.5 cm was established between the internal surface of the buccal bone and the internal surface of the palatal bone. The space was filled with wax and that was used to fix a human canine root with root canal previously prepared. The root was inserted up to the point where the cemento-enamel junction coincided with the level of the alveolar crest. The distances between the bone segments and the wax filling allowed the simulation of the periodontal ligament.

To evaluate the radiopacity of Epiphany (Pentron Clinical Technologies, Wallingford, CT, USA), AH Plus (De Trey - Dentsply, Konstanz, Germany) and Endofill (Dentsply HERO Indústria e Comércio Ltda, Petrópolis, RJ, Brazil), the endodontic sealers were prepared according to their manufacturer's instructions. The freshly mixed sealer was introduced into the polyethylene tubes (10mm X 1.5mm; Abott Lab do Brasil, São Paulo, SP, Brazil) and into acrylic wells (standard disc with 3mm of thickness X 4mm in diameter) with a syringe to avoid bubbles. The acrylic wells were placed over a glass plate covered by cellophane sheet. The tubes and the plates with the sealers were stored in a moist chamber at 37°C for 7 days for set.

The tubes with sealers, gutta-percha and Resilon cones (n=5 for each material) were placed in the root canal of the tooth positioned in the tissue simulator and radiographed. Periapical films (Insight; Eastman-Kodak Co, Rochester, NY, USA) were used, at a distance of 20 cm from the radiation source, using an apparatus (Timex 70C, Gnatus, Ribeirão Preto, SP, Brazil) set to work at 66 kVp, 6.5 mA and 0.5 seconds.

The standard discs with sealers (n=5) were also radiographed.

The films were processed in a deep tank with X-ray new solutions (Kodak, Rochester, NY, EUA), maintained at constant temperature, and digitized using a flatbed scanner with a transparency adapter (Epson Perfection 2450®, Long Beach, CA, USA). A black acrylic mask, standardizing the positioning of the film on the surface of the scanner, was used to limit the area of light incidence. The images were captured in their original size, with 300 dpi, 8 bit mode, providing 256 gray levels and stored in JPEG format with 3:1 compression ratio.

To obtain optical density values, the digital images were analyzed by Adobe Photoshop® software (v. 8.0, Adobe Systems, San José, EUA), using the histogram tool.

For the cones evaluation, an area of interest (336 pixels) in cervical third of the root canal was selected and images of the cone and of the dentin of the root were obtained.

For the endodontic sealers evaluation, an area of interest was selected in each sample. A standard size circle was drawn in the center of the standard disc (Figure 1). In the images obtained by the tubes, two standard size rectangles, one under the tube and other under the dentin, were drawn on the cervical third of the root (Figure 1).

The average and standard deviation of the grayscale pixel values – 0 (black) to 256 (white) – of the area selected were measured and registered, considering radiopaque materials with higher values and radiolucent with lower values.

To compare the radiopacity between the sealers, considering each method independently, data were subjected to statistical analysis using 1-way analysis of variance (ANOVA) and Tukey test. To compare both methods, data were evaluated by independent t-Test. To compare the data obtained to dentin and sealers in tubes method, the dependent t-Test was used.

The Wilcoxon statistical test was used to compare the radiopacity between the cones and the dentin, and the Mann-Whitney test was used to compare gutta-percha and Resilon cones.

Significance level was set at 5% and data were processed using SPSS version 10.0.

RESULTS

Data obtained with the simulator demonstrated that AH Plus and Epiphany behaved similarly, presenting higher gray value than Endofill, suggesting superior radiopacity. All tested sealers showed superior radiopacity than dentin ($P<0.05$) (Table 1).

Standard discs exhibited significant higher gray values when compared with sealers in the simulator ($P<0.05$). AH Plus was the most radiopaque followed by Epiphany and Endofill ($P<0.05$) (Table 2).

Resilon cones presented higher gray values than gutta-percha cones, suggesting superior radiopacity ($P<0.05$). The dentin demonstrated an inferior gray value in relation to the materials tested ($P<0.05$) (Table 3).

DISCUSSION

The present investigation showed, as it was expected, the loss of endodontic sealers radiopacity when occur overlapping of tissues and anatomical structures. In this context, the presence of bony trabeculae and soft tissues is an important feature when the radiopacity is being investigated (7, 10). 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 (11, 12, 13).

The sealers in standard discs presented higher gray values than the ones obtained in the tubes inside the simulator tissue block. Furthermore,

higher gray values were found in sealers comparing to dentin in both methods, proving that these materials present enough radiopacity to be identified in clinical conditions.

It is important to observe that the zinc oxide and eugenol based sealer (Endofill) showed lower radiopacity than the two resin-based sealers, independently of the method adopted for evaluation.

AH Plus and Epiphany were different from each other only when evaluated in standard discs. As well as in previous studies (5, 14, 15, 16), AH Plus presented superior results when compared to other resin-based sealers. Unlike the results presented herein, Garrido et al (17), using standard discs, did not find differences between AH Plus and Endofill.

In this regard, the differences observed are probably related to radiopacity agents. Endofill sealer contains bismuth subcarbonate and barium sulphate (17); AH Plus contains zirconium oxide, iron oxide and calcium tungstate (12, 15); and Epiphany contain silane-treated barium-borosilicate glass in addition to barium sulphate, bismuth and silica (18).

Gutta-percha and Resilon cones presented higher gray pixel values when compared with dentin. Moreover, Resilon cones showed higher values of optical density than gutta-percha.

The comparison of the two assessment methods for sealers radiopacity tests has validated the use of a tissue simulator block, considering clinical reality. The choice of imaging system may affect radiopacity measurements (19), however, the use digitized images is a viable option for the analysis of the radiopacity of endodontic sealers (20). The methodology used in the present study is simple and accessible and can provide reliable results.

CONCLUSION

In conclusion, the results of the present study demonstrated that all sealers showed appropriate values of radiopacity, presenting higher values than dentin and allow distinguishing itself from the tooth and the surrounding structures. AH Plus was the most radiopaque material, independently of the method used. The methodology proposed for simulating clinical situations revealed to be adequate in the assessment of the radiopacity of dental materials.

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TABLES

Table 1. Mean and standard deviation (SD) of the grayscale values (pixels) in the tubs containing the sealers (AH Plus, Epiphany, Endofill) and to dentin in the simulator

	Tube	Dentin
	Mean±SD	Mean±SD
AH Plus	126.47 (±3,86) ^{Aa}	96.43 (±3,86) ^b
Epiphany	124.56 (±2,87) ^{Aa}	97.51 (±3,69) ^b
Endofill	109.53 (±2,87) ^{Ba}	93.20 (±0,69) ^b

* Different capital letters indicate a statistically significant difference between sealers (ANOVA, Tukey $P < 0.05$).

* Different lower letters indicate a statistically significant difference between sealers and dentin (Dependent t-Test $P < 0.05$).

Table 2. Mean and standard deviation (SD) of the grayscale values (pixels) to the sealers (AH Plus, Epiphany, Endofill), according to the method.

Sealer	Standard discs		Tubes	
	Mean±SD		Mean±SD	
AH Plus	241.19±4.65	Aa	126.47±3.86	Ab
Epiphany	224.92±3.80	Ba	124.56±2.87	Ab
Endofill	205.04±0.75	Ca	109.53±2.87	Bb

* Different capital letters indicate a statistically significant difference between sealers to each method (ANOVA, Tukey $P < 0.05$).

* Different lower letters indicate a statistically significant difference between methods to each sealer independently (Independent t-Test $P < 0.05$).

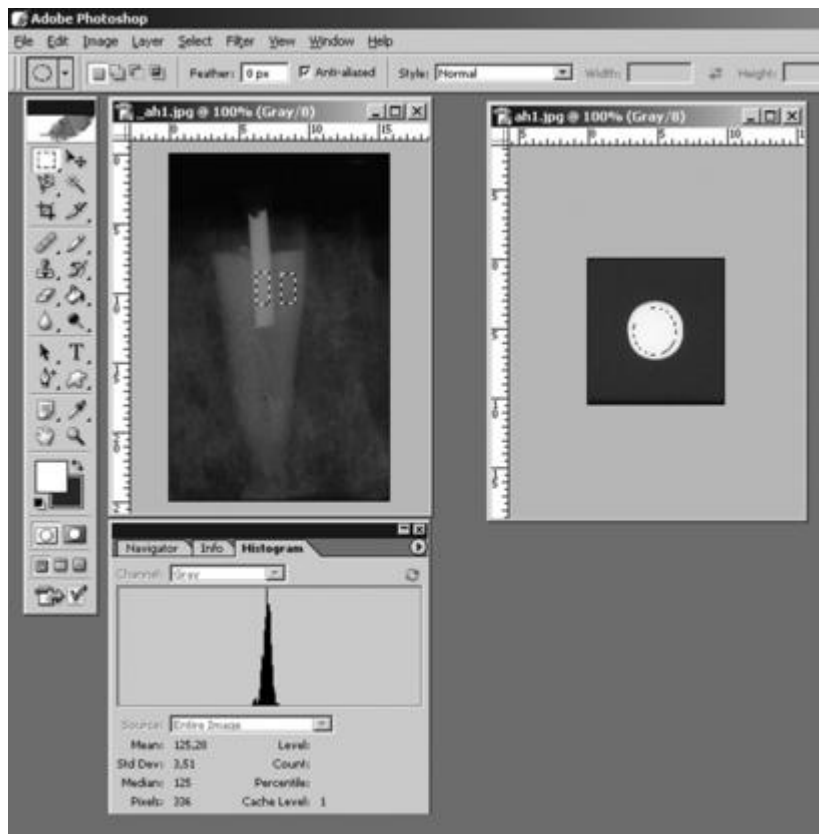
Table 3. Mean values and standard deviation of the grayscale values (pixels) for gutta-percha, Resilon cones and dentin.

Gutta-percha	Dentin	Resilon	Dentin
125.67 ^{A*}	112.46 ^B	131.93 ^{a**}	111.98 ^b
±0.45	±0.56	±0.41	±0.48

[†]Different capitals letters indicate that gutta-percha and dentin differs significantly ($p=0.043$) and different lower letters indicate that Resilon and dentin differs significantly ($p=0.043$) by Wilcoxon test; different number of asterisks indicate that gutta-percha and Resilon differs significantly ($p=0.008$) by Mann-Whitney test.

FIGURE LEGEND

Figure 1 – Adobe Photoshop® software showing the image obtained of tubes and standard discs methods and areas of interest selected.



CONSIDERAÇÕES FINAIS

O presente estudo demonstrou a importância de se avaliar a radiopacidade de materiais obturadores endodônticos com metodologias que simulem a situação clínica, pois existe perda da radiopacidade dos mesmos quando estes são avaliados com a presença de trabeculado ósseo, dentina e tecidos moles.

Os resultados obtidos nesta pesquisa foram semelhantes a outros estudos que mostram a superior radiopacidade do cimento AH Plus quando utilizada metodologias sem influências de sobreposição de estruturas (TANOMARU *et al.*, 2004; TANOMARU *et al.*, 2007; GORDUYSUS e AVCU, 2009; MARIN-BAUZA *et al.*, 2010). No momento em que foi utilizado o bloco simulador de tecidos, a radiopacidade de todos os cimentos reduziu.

É importante salientar que todos os cimentos estudados apresentaram valores de cinza superiores à dentina, provando que estes materiais tem radiopacidade suficiente para serem identificados em situações clínicas.

O cimento à base de óxido de zinco e eugenol apresentou menor radiopacidade que os outros cimentos testados em ambas as metodologias, semelhante resultado foi encontrado por Gorduysus e Avcu em 2009. Essa diferença está atribuída aos agentes que transferem radiopacidade em cada cimento testado.

Os cones de guta-percha e Resilon obtiveram valores de cinza superiores quando comparados com a dentina e os cones de Resilon mostraram maiores valores de densidade óptica que a guta-percha.

A metodologia proposta neste estudo para simular as condições clínicas mostrou-se adequada na avaliação da radiopacidade de materiais endodônticos obturadores.

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