Evaluation of the gray level of restorative materials using cone-beam computed tomography: A cross-sectional study

Ocena poziomu szarości materiałów stomatologicznych w tomografii stożkowej – badanie przekrojowe

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Abstract

Background. Densitometry plays an important role in the diagnosis of different types of dental materials and treatment planning. Due to diversity in density, equal amounts of different materials absorb various amounts of X-rays and yield different radiographic views.

Objectives. The aim of this study was to evaluate the gray scales of 5 commercially available restorative materials, including amalgam, composite resin, flowable composite resin, glass-ionomer, and Dycal.

Material and methods. Samples of the 5 test materials from various manufacturers were prepared, each 5-millimeter-thick. There were 7 glass-ionomer samples and 10 of each of the other materials, making a total of 47 samples in the study. The test materials were scanned using a Kodak cone-beam computed tomography (CBCT) unit. Subsequently, the gray scales were determined and evaluated by a radiologist using OnDemand3D™ Dental software and analyzed with SPSS v. 22 software.

Results. Amalgam had a higher gray scale than the other groups of restorative materials. In some cases, it was the same as that of composite resin; however, it was significantly different from gray scales of flowable composite resin, glass-ionomer and Dycal. It was concluded that composite resin and amalgam were high in gray scale, while flowable composite resin, glass-ionomer and Dycal exhibited low gray scales.

Conclusions. Amalgam and composite resin had high gray scales, and glass-ionomer and Dycal exhibited the lowest gray scale values. The findings show that CBCT can be helpful in differentiating amalgam and composite resin from other materials.

Key words: cone-beam computed tomography, dental materials, densitometry

Słowa kluczowe: stożkowa tomografia komputerowa, materiały dentystyczne, densytometria

Introduction

One of the main issues playing an important role in the assessment of different dental materials and in treatment planning is densitometry. For example, distinguishing the density of bone undeniably affects the success of dental implants.¹ In addition, in the case of maxillofacial trauma or a foreign body suspected in the surrounding soft tissue, densitometry can be used to determine the kind of the foreign body, which might be a restorative material. Densitometry is also useful while distinguishing restorative materials used in older treatment plans from each other and from the recent ones, which can be of great importance in dental treatment planning.^{2,3} Equal amounts of different materials, due to differences in their atomic number and density, result in differences in the attenuation of X-rays. As a result, they have different radiographic projections even on plain films. Therefore, given the density of any material, its nature can be determined through radiography.⁴ Denser materials have less space in their crystal networks and their molecules are highly compressed. These substances absorb much more X-ray radiation when they are exposed to X-rays, since they have more atoms and more electrons.^{5,6}

X-rays are used to produce images from opaque materials based on the relationship between the density and X-ray absorption of different materials.⁷ Different techniques, such as computed tomography (CT) and cone-beam computed tomography (CBCT) can be used.

In the CT technique, one number is assigned to each pixel displaying the images and this shows the rate of attenuation of rays by each tissue. Computed tomography numbers are known as Hounsfield units (HU). In 1978, this technique was introduced in bone densitometry. Various studies have recognized CT as the gold standard for tissue densitometry.⁸

The CBCT technique is of great importance in head and neck traumas. In recent years, CBCT has also been used as a critical diagnostic tool in dentistry^{9–13} and it is an innovative technique in scanning and data reconstruction. Cone-beam computed tomography is widely used for 3-dimensional and multiplanar images. Compared to CT, this method can provide detailed images – up to sub-millimeter resolution – in a shorter time and at a lower dosage; in addition, it is more affordable for patients. However, CBCT has shortcomings as well. The quality of reconstructed CBCT images is affected by noise, beam hardening, the cone-beam effect and photon starvation. These effects result in the formation of different types of artifacts, such as bright streaks of radiation, dark areas adjacent to metal objects or even a complete loss of gray shadows between adjacent metal objects. Beam hardening results from the preferential absorption of lower-energy photons in a heterogeneous X-ray beam. As opposed to rectangular objects, in spherical and cylindrical objects, like the skull and implants, the distance through

the center is longer than a path closer to the surface, the central area can appear as a dark area with a decreased CT number (HU) in the middle of axial cuts.¹⁴ Nevertheless, recent research shows that by analyzing gray scales, CBCT can determine HU of tissues and, as a result, the densities of different bones.^{14,15} There are limited studies on the use of CBCT to determine the density of restorative materials.¹⁵

The aim of this study was to evaluate the gray levels of materials in restorative dentistry, using CBCT in standard exposure, which could help to assess the materials, and thus improve treatment planning.

Material and methods

This pilot study is one of the first studies on evaluating the gray levels of dental restorative materials with the use of the CBCT technique. Each group of substances consisted of 10 different products from various manufacturers, except for the glass-ionomer group, which included 7 samples, making a total of 47 samples of restorative materials evaluated in 5 groups.

The technical specifications of the 5 substances, commonly used in restorative dentistry, evaluated in this study are as follows:

- amalgam: A – ANA 2000® (Nordiska Dental, Ängelholm, Sweden); B – GS-80® (SDI, Itasca, USA); C – Cinalux® (Shahid Faghihi, Tehran, Iran); D – GK® (AT&M Biomaterials, Beijing, China); E – GK-110® (AT&M Biomaterials, Beijing, China); F – Wykalloy® (Prestige Dental Products, Anaheim, USA); G – Aristaloy 21® (Lavadent, London, UK); H – World Work Powder Alloy® (World Work, Montebello Vicentino, Italy); I – Contour® (Kerr, Orange, USA); J – 110-Plus® (Anas Dental Supplies, Damascus, Syria);
- composite resin: A – SDI Luna® (SDI, Itasca, USA); B – Coltene-Synergy® (Coltene Whaledent Inc., Cuyahoga Falls, USA); C – Filtek Z250-XT® (3M, Seefeld, Germany); D – Opallis® (FGM, Joinville, Brazil); E – Bisco-Aelite Aesthetic Enamel® (Bisco, Schaumburg, USA); F – Estelite Sigma Quick® (Tokuyama, Tokyo, Japan); G – Shofu-Beautifil II® (Shofu, Kyoto, Japan); H – Denfil® (Vericom, Anyang, South Korea); I – Diafil® (Diadent, Cheongju, South Korea); J – Charmfil Plus® (Dentkist, Seoul, South Korea);
- flowable composite resin: A – Denfil Flow® (Vericom); B – Diafil Flow® (Diadent); C – Denu Flow Resin® (HDI-Denu, Seoul, South Korea); D – Permaflo Pink® (Ultra Dent, South Jordan, USA); E – Clearfil AP-X Flow® (Kuraray, Chicago, USA); F – Opallis Flow® (FGM); G – Heliomolar Flow® (Ivoclar Vivadent, Mississauga, Canada); H – Tetric N-flow® (Ivoclar Vivadent, Mumbai, India); I – Wave® (SDI, Itasca, USA); J – Filtek Z350-XT® (3M);
- glass-ionomer: A – Riva Luting® (SDI, Bayswater, Australia); B – GC Fuji I® (GC, Tokyo, Japan); C – Tokuso Ionomer® (Tokuyama); D – Chemfil Superior® (Dentsply,

Tulsa, USA); E – Ionoseal® (VOCO, Cuxhaven, Germany); F – Iono Cid-LC® (FSDS, Greenock, Canada); G – Glass Liner® (WP Dental, Barmstedt, Germany); – Dycal: A – ACTIVA Bioactive-base/liner® (Pulpdent Corporation, Watertown, USA); B – Dycal Ivory® (Dentsply); C – ANA Liner® (Nordiska Dental, Ängelholm, Sweden); D – Biner-LC® (Meta Biomed, Cheongju, South Korea); E – Hidrox-Cal® (Maquira, Maringá, Brazil); F – Theracal LC® (Bisco); G – Ionosit-Baselinier® (DMG Chemisch-Pharmazeutische, Hamburg, Germany); H – Master Dent Cavity Liner® (Master Dent, Garden Grove, USA); I – Ultra Blend Plus® (Ultra Dent, South Jordan, USA); J – Charmfil Flow® (Dentkist).

To prepare the test set, a cardboard grid measuring $135 \times 60 \times 1$ mm was selected and a collection of cubes with the same size ($5 \times 5 \times 5$ mm) was made of it (Fig. 1). The rows show the material types used and the columns show the manufacturers. Each material was placed in one of the cubes and the samples were prepared for final setting according to the same clinical procedure. The preparation procedures were as follows: amalgam samples were packed using a condenser, and composite resin samples were light-cured layer by layer; to light-cure flowable composite resin, glass-ionomer and Dycal, a light-curing unit was used (Fig. 2).

After the final setting, the restorative materials were separated from the cardboard grid and each group of materials was laid on a separate sheet. The composite resin, flowable composite resin, glass-ionomer, and Dycal samples were placed on 4 separate cardboards with a distance of 1.5 cm between them (Fig. 3). For the amalgam samples, a little more space was left between them (about 2 cm) due to artifacts made by amalgam during image acquisition (Fig. 4). It should be pointed out that there was a limitation to the cardboard sheet size, since a larger size would have been out of the field of view of the CBCT system. In addition, since the space between the amalgam samples was more than that between other materials, each sample had to be scanned separately.

Fig. 1. A cardboard grid fabricated for the placement of the restorative materials

Fig. 2. Squares of the cardboard grid filled with the restorative materials

Fig. 3. A – composite resin; B – flowable composite resin; C – glass-ionomer; D – Dycal cubes attached to the cardboard sheet with a distance of 1.5 cm between them

Fig. 4. Amalgam cubes attached to the cardboard sheet with a distance of 2 cm between them

Each cardboard sheet holding 1 of the restorative materials was exposed to a CBCT system (Kodak CBCT, Carestream Company, Rochester, USA) under standard exposure conditions (MA = 6.3, kVp = 73, voxel = 180). The acquired images were analyzed by an experienced radiologist in a horizontal view, using OnDemand3D™ Dental software (Cybermed, Seoul, South Korea) and the gray scale of each sample was recorded by determining the mean, min and max values at the center of the sample (Fig. 5,6).

The gray levels were determined at the center of the samples to minimize the artifact effect. It should be pointed out that cubic and homogeneous samples were used in the present study to eliminate the beam-hardening effect, which is a problem in spherical, cylindrical and non-homogeneous samples. The samples were completely identical and the artifact effect, if any, would affect them all similarly.

Fig. 5. The cone-beam computed tomography (CBCT) image of amalgam cubes scanned by a Kodak CBCT system

The data was recorded in checklists and analyzed with SPSS v. 22 software (IBM Corp., Armonk, USA). The gray scale was evaluated using means and standard deviations (SDs) at a 95% confidence interval (CI), separately for each dental material under standard exposure conditions. An analysis of variance (ANOVA) was used to compare the means of gray scales in the dental materials under exposure conditions and between different materials. Post-hoc Tukey's tests were used for two-by-two comparisons of the mean gray scale values of the dental materials. In the cases when the gray scale data was not normally distributed, corresponding non-parametric tests were used. Statistical significance was set at $p < 0.05$.

Results

The data in Table 1 shows that the highest min gray scale value among the samples in the study was exhibited by amalgam ($10,160.20 \pm 1,766.53$; 95% CI: 8,896.50–11,423.90). Dycal exhibited the lowest min gray scale value among the restorative materials in the study ($4,861.00 \pm 1,159.35$; 95% CI: 4,031.65–5,690.35). Based on a one-way ANOVA, the 5 restorative materials in the study showed significant differences in the min gray scale values ($p = 0.001$).

The data in Table 1 shows that the highest max gray scale value was exhibited by amalgam ($14,554.1 \pm 2,927.9$; 95% CI: 12,459.63–16,648.57). The lowest max gray scale value belonged to glass-ionomer ($8,192.29 \pm 4,172.52$; 95% CI: 4,333.34–12,051.23), indicating a significant difference in the max gray scale values based on a one-way ANOVA ($p = 0.001$).

Fig. 6. The cone-beam computed tomography (CBCT) images of: A – composite resin; B – flowable composite resin; C – glass-ionomer; D – Dycal cubes, scanned by a Kodak CBCT system

Table 1. Comparison of the min and max gray scale values in 5 restorative materials

Types of dental materials		Descriptives							
		n	mean	SD	95% CI		min	max	p-value
					lower bound	upper bound			
Min	amalgam	10	10,160.20	1,766.53	8,896.50	11,423.90	7,703.00	13,193.00	0.001
	composite	10	7,248.90	2,690.49	5,324.24	9,173.56	2,839.00	11,188.00	
	composite flow	10	6,491.40	3,279.22	4,145.59	8,837.21	1,723.00	10,544.00	
	glass-ionomer	7	6,248.14	3,582.88	2,934.53	9,561.75	232.00	9,639.00	
	Dycal	10	4,861.00	1,159.35	4,031.65	5,690.35	2,864.00	6,494.00	
Max	amalgam	10	14,554.10	2,927.87	12,459.63	16,648.57	10,474.00	19,335.00	0.001
	composite	10	9,306.00	3,017.59	7,147.35	11,464.65	4,263.00	14,888.00	
	composite flow	10	9,457.30	4,713.73	6,085.30	12,829.30	4,476.00	18,368.00	
	glass-ionomer	7	8,192.29	4,172.52	4,333.34	12,051.23	1,906.00	14,798.00	
	Dycal	10	8,269.60	2,081.21	6,780.80	9,758.40	5,816.00	12,905.00	
Mean	amalgam	10	11,253.70	1,706.37	10,033.03	12,474.37	8,433.00	13,765.00	0.009
	composite	10	8,217.50	2,768.59	6,236.97	10,198.03	3,644.00	12,503.00	
	composite flow	10	7,713.10	3,698.44	5,067.39	10,358.81	2,660.00	12,286.00	
	glass-ionomer	7	7,252.57	3,835.23	3,705.57	10,799.57	1,276.00	12,583.00	
	Dycal	10	6,692.80	1,837.25	5,378.51	8,007.09	4,145.00	10,927.00	

SD – standard deviation; CI – confidence interval.

The analysis of the mean gray scale values of the restorative materials (Table 1) shows that the highest value was displayed by amalgam (11,253.7 ± 1706.37; 95% CI: 10,033.03–12,474.37). The lowest mean gray scale value was found in Dycal (6,692.80 ± 1,837.25; 95% CI: 5,378.51–8,007.09), indicating a statistically significant difference in the mean gray scale values among the 5 restorative materials in this study based on a one-way ANOVA ($p = 0.009$).

Post-hoc Tukey's tests were used to compare the min, max and mean gray scale values. Using pair-wise analyses of the restorative materials, it was concluded that the min value of amalgam was significantly different from all

the other materials except for composite resin. It is worth noting that flowable composite resin exhibited a borderline significant difference from amalgam in the min gray scale value.

Regarding the gray scale max value, in pair-wise comparisons of the restorative materials, amalgam exhibited the following statistically significant differences from the other materials: composite resin ($p = 0.013$), flowable composite resin ($p = 0.016$), glass-ionomer ($p = 0.005$), and Dycal ($p = 0.002$). Amalgam had the highest max gray scale value of all the materials. Other materials, however, did not show a statistically significant difference in the above test ($p > 0.05$).

Table 2. The min, max and mean gray scale values in different brands of 5 restorative materials

Brands*	Type of dental material														
	amalgam			composite			flowable composite			glass-ionomer			Dycal		
	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean
A	11,435	16,427	12,521	2,839	4,263	3,644	3,809	5,418	4,907	4,031	5,440	4,785	6,494	8,883	7,368
B	11,264	19,335	12,703	7,491	9,497	8,498	9,052	10,567	9,552	5,690	6,924	6,243	5,401	7,148	6,144
C	11,838	19,011	13,207	6,342	7,897	7,091	6,891	7,961	7,359	9,602	14,798	12,583	4,888	6,832	5,931
D	9,220	12,069	10,150	10,313	11,613	10,972	10,434	13,687	11,563	232	1,906	1,276	4,804	12,905	10,927
E	9,591	12,326	10,425	6,731	9,479	7,975	7,851	18,368	12,286	9,639	10,670	10,034	5,297	9,802	5,940
F	9,849	13,837	10,801	4,397	6,298	5,237	8,318	12,103	10,061	9,591	10,422	9,970	5,008	7,689	6,381
G	7,771	13,955	9,842	6,416	8,484	7,386	2,601	4,510	3,325	4,952	7,186	5,877	2,864	5,816	4,145
H	9,738	13,115	10,690	10,415	12,082	11,456	10,544	12,318	11,293	–	–	–	6,050	7,618	6,663
I	13,193	14,992	13,765	6,357	8,559	7,413	3,691	4,476	4,125	–	–	–	4,819	6,498	5,308
J	7,703	10,474	8,433	11,188	14,888	12,503	1,723	5,165	2,660	–	–	–	2,985	9,505	8,121

* The letters A–J represent different brands according to the description in section "Material and methods".

The results of pair-wise analyses of the mean gray scale values showed that amalgam was significantly different from glass-ionomer ($p = 0.048$) and Dycal ($p = 0.007$). The difference between amalgam and flowable composite resin was borderline significant ($p = 0.057$), while the difference between amalgam and composite resin was not significant ($p = 0.136$). Based on Tukey's honest significant difference (HSD) tests, the other restorative materials did not exhibit significant differences in the mean values in pair-wise comparisons.

Amalgam had higher min, max and mean gray scale values than the other restorative materials. It exhibited the same gray scale value as composite resin in some cases, but was significantly different from glass-ionomer, Dycal and flowable composite resin. It can be concluded that composite resin and amalgam were high in gray scale, and flowable composite, glass-ionomer and Dycal exhibited low gray scale.

Table 2 presents the min, max and mean gray scale values of the restorative materials in terms of their brands. The results show that among the amalgam samples, Kerr had the highest min and mean values, and SDI had the highest max gray scale value compared to the other brands.

Among the composite brands, Dentkist exhibited the highest min, max and mean gray scale values, and the lowest values belonged to SDI.

Among the flowable composite resins, the highest max and mean gray scale values belonged to Kuraray, and the highest min gray scale level was found in Ivoclar Vivadent, India. The lowest min and mean gray scale values belonged to 3M, and the lowest max gray level belonged to SDI.

Out of the 7 glass-ionomer brands, the highest max and mean gray scale values belonged to Tokuyama, and the lowest values were found in Dentsply.

In Dycal, the highest min gray scale value belonged to Pulpdent Corporation, and the lowest max, min and mean values belonged to DMG Chemisch-Pharmazeutische.

The min, max and mean gray scale values of different restorative materials in terms of their brands are presented in Fig 7–9.

The min gray scale value was higher in amalgams than in the other restorative materials. Glass-ionomer and Dycal had a lower value than the other restorative materials. Composite resin and flowable composite resin were in the middle of the range.

Among the amalgam samples, the max gray value belonged to SDI and the min value belonged to Anas Dental Supplies. Among the composite resins, the max was found in Dentkist and the min was noted in SDI. Flowable composite resins showed their max and min values in Kuraray and 3M, respectively. Glass-ionomer exhibited the max and min values in Tokuyama and Dentsply, respectively. Finally, in Dycal, the max and min gray scale values belonged to Meta Biomed and DMG Chemisch-Pharmazeutische, respectively.

Fig. 7. Minimum gray scale values of restorative materials in relation to their brands

Fig. 8. Maximum gray scale values of restorative materials in relation to their brands

Fig. 9. Mean gray scale values of restorative materials in relation to their brands

Discussion

Cone-beam computed tomography has been used as an important diagnostic tool in recent years.^{9–13} It is an innovative method in scanning and image reconstruction. In this technique, materials with different densities, such as bone and soft tissue, can be differentiated based on their densitometry. Several studies have been conducted in this regard, but only a few have evaluated the density of restorative materials commonly used in dentistry.

Among these studies, Lachowski et al. analyzed the radiopacity of various dental materials (bases and liners).¹⁶ They used digital intraoral radiography (Kodak; radiovisiography (RVG): 5000, 70 kVp, 7 mA, 0.32 s, 30-centimeter distance). As in the present study, Tetric N-flow was among the flowable composite resins. With a thickness of 3 mm, this material exhibited the highest gray scale. It had the second highest gray scale value in the present study, consistent with the results of the study by Lachowski et al. It must be pointed out that the gray scale value of a material is directly related to its density. Considering this and the results of the present study, in the category of flowable composite resins, the lowest gray scale value belonged to the most flowable one. The same cannot be said with certainty regarding glass-ionomers, because they are supplied as 2-part powder and liquid systems that require mixing, depending on their different therapeutic applications. Glass-ionomers are sometimes used in a creamy consistency to line dental caries, but in class V restorations on the root surface, they are used in a thicker consistency.

By scanning samples of different sizes, Lachowski et al. concluded that the thickness of the samples had a direct effect on the final radiography. Thicker samples had a greater amount of substance, and thus more X-ray attenuation was observed¹⁶. In the present study, all the samples for scanning were prepared in the same dimensions and their thickness was fixed at 5 mm. In addition, the sub-categories of each group of restorative materials were compared to each other in terms of the min and max gray scale values, with a direct relation between density and gray scale values resulting from the CBCT images.

Although intraoral digital imaging is less costly than CBCT, since it does not provide a value level as the output of the radiopacity analysis, the materials in the study by Lachowski et al. were measured with a single opaque item. In that study, the opacity of the materials in aluminum sheets of different thicknesses were evaluated. The ingredients of aluminum sheets vary and this affects their opacity. Furthermore, the opacity of the study samples, compared to the opaque aluminum sheet, was evaluated with the use of relative measurements.¹⁶ However, in the present study, the CBCT technique was used to capture images, which had the advantage of higher resolution and accuracy compared to other imaging systems.

In another study, Devito et al. compared the radiopacity of 3 types of calcium hydroxide (Dycal, Hydro-C, Life) using digital radiography. They concluded that the radiopacity of the cement and enamel was equal to 2 mm of aluminum, but the radiopacity of the dentin was equal to 1 mm of aluminum. In that study, the lowest opacity belonged to Life.¹⁷ In the present study, among the 10 different types of Dycal, the least opacity was noted for Ionosit-Baseline and the highest for Biner-LC. Hidrox-Cal, which was assessed both in this study and in the study by Devito et al., was in the middle of the spectrum.

Pires de Souza et al. investigated the optical densities of calcium hydroxide and glass-ionomer, concluding that in order to assess the radiopacity of different materials, the min thickness of the samples must be approx. 1.5–2 mm.¹⁸ In the present study, the thickness of each sample was 5 mm. It is consistent with the above-mentioned authors, who used intraoral radiography to examine the opacity of the materials.

In research conducted by Imperiano et al., intraoral radiography and materials of equal thickness (2×10 mm) were used to measure the density of different composite resin types. In that study, Natural Flow and Protect Liner F composite resins did not exhibit any specific opacity that would allow them to be differentiated from dental caries.¹⁹ However, in the present study, none of the composite resins exhibited a significant difference from amalgam and all had the necessary opacity for differentiation from the tooth structure. This discrepancy between the results of studies might be attributed to differences in research methods. In addition, none of the brands evaluated in the present study was used in the study by Imperiano et al.

Factors affecting the results obtained from CBCT include the scanning conditions and the type of device.^{4,8,20,21} Therefore, to determine the gray scale of different restorative dental materials, a single CBCT device was used.

As discussed above, in the CT technique one number is assigned to each pixel, which indicates the amount of radiation attenuated by the studied tissue.⁸ This is one of the differences between CT and CBCT, and the lack of real HU (as in CT) is a disadvantage of CBCT. Mah et al. examined the different structures of 11 dental CBCT units and 2 medical CT systems. The results showed that there was a high correlation between HU in CT and the gray scale in CBCT.²¹ In the present study, CBCT was used instead of CT due to its greater advantages, such as low-dose radiation, high precision in supplying images at shorter scan times, higher resolution and clarity, and lower cost compared to medical CT.

In a study by Razi et al., the soft tissue of a sheep's head was used.⁴ Mah et al. placed specimens in a bowl of water in order to simulate soft tissue to some extent for X-ray attenuation.²¹ However, Parsa et al. used a dry mandible.²⁰ In the present study, an attempt was made to obtain a number for the gray scale value of the restorative materials by eliminating confounding factors, such as facial soft tissue, tongue and saliva in order to provide a background for future studies.

In another study, Emadi et al. compared different samples of restorative materials and reported that amalgam and AH-26 had the highest gray scale value. Zinc phosphate, gutta-percha and zinc oxide eugenol had the second place, followed by MTA and polycarboxylate.⁸ In the present study, amalgam, composite resin, flowable composite resin, glass-ionomer, and Dycal were studied, and the highest gray scale value was noted for amalgam; this was consistent with the results reported by Emadi et al. In the present study, Dycal exhibited the lowest gray scale.

Conclusions

The results of the present study show that CBCT can be efficient in differentiating amalgam and composite resin from other materials, such as flowable composite resin, glass-ionomer and Dycal. This is a pilot study; therefore, in further studies we will compare this value in different CBCT and multi-row-detector computed tomography (MDCT) systems.

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