Radiodensity evaluation of dental impression materials in comparison to tooth structures

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ABSTRACT

In the most recent decades, several developments have been made on impression materials' composition, but there are very few radiodensity studies in the literature. It is expected that an acceptable degree of radiodensity would enable the detection of small fragments left inside gingival sulcus or root canals. Objective: The aim of this study was to determine the radiodensity of different impression materials, and to compare them to human and bovine enamel and dentin. Material and Methods: Twenty-five impression materials, from 5 classes, were studied: addition and condensation silicones, polyether, polysulfides and alginates. Five 1-mm-thick samples of each material and tooth structure were produced. Each sample was evaluated 3 times (N=15), being exposed to x-ray over a phosphor plate of Digora digital system, and radiodensity was obtained by the software Digora for Windows 2.5 Rev 0. An aluminum stepwedge served as a control. Data were subjected to Kruskal-Wallis and Dunn's method (α=0.05). Results: Different materials and respective classes had a different behavior with respect to radiodensity. Polysulfides showed high values of radiodensity, comparable to human enamel ($p>0.05$), but not to bovine enamel ($p<0.05$). Human dentin was similar only to a heavy-body addition silicon material, but bovine dentin was similar to several materials. Generally, heavy-body materials showed higher radiodensity than light-body ones ($p<0.05$). Conclusion: Impression materials' radiodensity are influenced by composition, and almost all of them would present a difficult detection against enamel or dentin background in radiographic examinations.

Key words: Radiography. Dental impression materials. Enamel. Dentin. Human tooth. Bovine tooth.

INTRODUCTION

Impression materials are largely used to record the geometry of hard and soft dental tissue during dental treatment or to record the relations of teeth with the surrounding tissues[2]. These materials can be classified into elastic and non-elastic, and the two groups of the elastic ones are the hydrocolloids (e.g., alginates) and the elastomers (polysulfides, condensation silicones, addition silicones and polyethers). Elastic recovery, accuracy, strain in compression, tear energy and tensile strength are some of the commonly investigated properties which enables the development of better materials[18,29], but radiodensity measurement studies are uncommon[8,23,24] for new materials. Irrespective of the impression technique, all dental impression materials are introduced into the oral cavity right after having been mixed and come in direct contact with the oral tissues. Under this condition, the materials may be toxic to cells or may sensitize the tissues[20]. Some studies have reported allergic responses to impression materials and their potential cytotoxicity, even if the period of contact with oral tissues is short[4,6,19,20,26]. Therefore, if materials with low tear strength are left around or under gingival margins without any perception by the dentist, an inflammatory response may possibly rise with time. In addition to the potential cytotoxicity, by means of a radicular impression for indirect fabrication of post-and-cores[22], fragments can be left inside root canals making it difficult to adapt cast metal posts; otherwise, these materials can act as foreign bodies whose aspiration by patient can result is serious problems[5].

It is generally accepted that materials should be sufficiently radiopaque to be detected against a background of enamel and dentin[1,11,27]. The radiopacity degree required for ideal clinical performance can vary within the same class of material[14]. Common methods for evaluation of density of radiographic images employ conventional x-ray films and densitometers[14,15] or spectrophotometers[30]. Since 1987, alternatives to silver-halide receptors for intraoral radiographic imaging have included CCD-based systems and storage phosphor technology[9]. Digital intraoral radiography reduces patients' exposure to x-rays[29], permits the improvement of image quality by image manipulation, it is faster and less expensive than conventional techniques and easy to use[28] and also enables the accurate evaluation of radiodensity[13].

In the past 20 years, after constant development of impression materials, very few studies have investigated their radiodensity[23,24]. It is hypothesized that an acceptable degree of radiodensity would enable the detection of small fragments left inside gingival sulcus or root canals. Thus, the aim of this study was to evaluate the radiodensity of different impression dental materials and to compare the results to the radiodensity of human and bovine enamel and dentin.

MATERIAL AND METHODS

Twenty-five different dental impression materials were employed in this study. Material types, commercial names, manufacturers and composition are listed in Figure 1. Five samples of each material were produced according to the manufacturers' instructions and inserted in a 1.0-mm-thick stainless steel mold with 4.0 mm in diameter to obtain standardized samples. Materials were mixed and allowed to set during the period recommended by each manufacturer. After removal of the samples from the mold, the thickness was checked with a digital caliper (Mytutoyo, Tokyo, Japan) in order to fit 1.0 mm (±0.1 mm). A 99%-pure aluminum stepwedge (12 steps) ranging from 1.0 mm to 12.0 mm in thickness served as a control.

Ten human third molars (H) from 20 to 30-year-old donators, and 10 bovine central incisors from 48-month animals[12], recently extracted, were selected and stored in 0.2% thymol (Biopharma, Uberlândia, MG, Brazil). All human teeth were collected in accordance with the Ethics Committee of Dental School of the State University of Campinas (#049/2006). The teeth were sectioned transversally with a diamond saw (KG Sorensen, Barueri, SP, Brazil) and ground with a 600-grit silicon carbide paper under running water in order to produce superficial dentin (D) or enamel (E) samples with 1.0±0.1 mm in thickness, checked with the digital caliper.

The samples were positioned over a phosphor plate and the radiographic exposition was performed using an x-ray machine (GE 1000, General Electric, Milwaukee, USA), exposing it for 0.2 s at 70 kV and 10 mA, with a source-to-sample distance of 40 cm. Three exposures were performed for each sample. The radiographs were transferred from the phosphor plate to the computer via a Digora scanner (Digora Optime; Soredex, Helsinki, Finland).

The radiodensity (in pixels) of the samples were determined with the resident software provided by the manufacturer. The Digora system has a Windows-based software (Digora for Windows 2.5 Rev, Soredex, Helsinki, Finland) that is capable to measure density curves of digital radiographies obtained by x-ray impregnation on the image phosphor plate. The radiodensity of each radiographed material was obtained by clicking with the software cursor right above the digital image. Each digital image had its radiodensity measured immediately after scanning, without any modification in contrast or brightness. This software shows data concerning the highest and the lowest radiodensity of the sample, and an average value, which was considered to be the sample's initial radiodensity. Since each sample was submitted to three exposures, the sample's final radiodensity was considered to be the mean of those values.

For observations of materials filler characteristics, materials were examined using scanning electron microscopy (SEM) after dissolution of the organic matrix. Unmixed elastomer samples were soaked in 100% acetone (3 baths with centrifugation) and followed by 100% chloroform (3 baths with centrifugation)[21]. For alginates, just the powder was used for observations. Thereafter, the specimens were sputter-coated with gold (MED 010; Balzers Union, Balzers, Liechtenstein) and observed with a scanning electron microscope (DSM 940A; Zeiss, Oberkoshen, Germany).

Statistical analysis of data was performed using SPSS 12.0 for Windows (SPSS Inc., Chicago, IL, USA) and BioStat 3.0 (Sociedade Civil Mamirauá/MCT-CNPq, Brazil). Data were subjected to Shapiro-Wilk test of normality, Kruskal-Wallis and Dunn's Test (α=0.05). Comparisons were made among all impression materials, impression materials *versus* teeth structures, and materials allocated into groups of type of impression materials (addition silicon, condensation silicon, alginates and polyether plus polysulfides). The aluminum stepwedge was also compared to each group by Kruskal-Wallis and Dunn's Test. For all tests, groups were considered statistically different at α=0.05.

RESULTS

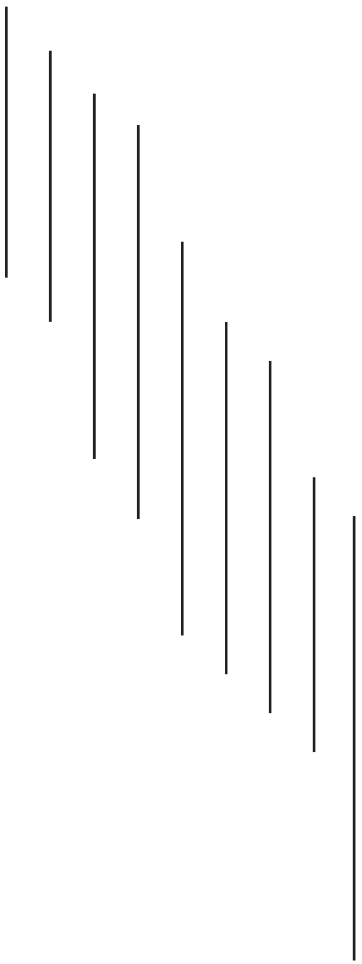
Table 1 and 2, and Figures 2-6 show the results of radiodensity measurements together with the statistical analysis. Radiodensity means and

Type	Commercial Name (Batch)	Manufacturer	Composition*
Polysulfide (PS)	Permlastic Regular (4-1217)	Kerr Corporation, Orange, CA, USA	*Base: polysulfide polymer, titanium or lithopone dioxide, dibutyl phthalate and sulfur. Catalyst: lead peroxide, titanium dioxide, Ba and Zn sulfide, dibutyl phthalate.*
	Permlastic Light (5-1103)		
Addition Silicone (AS)	Adsil Heavy Body (018/05)	Vigodent, Rio de Janeiro, Brazil	*Base: vinyl polysiloxane polymer, siloxane prepolymers, filler. Catalyst: vinyl polysiloxane polymer, siloxane prepolymers, filler platinum and palladium salts, surfactants and filler*
	Adsil Regular Body (06/05)		
	Adsil Light Body (08/05)		
	Virtual Extra Light Body (GL4178)	Ivoclar Vivadent, Schann, Liechtenstein	
	Aquasil Light (020502)	3M-ESPE, St. Paul, MN, USA	Vinyl polysiloxane polymer, silicones, silica, quartz, chromium oxide, and pigments
	Aquasil Extra-light (020412)		
	Express Light Body (4HEF1A3)		
	Reprosil A Putty (377613)	Dentsply Latin America, Petrópolis, RJ, Brazil	Hydrogen silicone, Vinyl polysiloxane polymer, silicone dioxide, titanium dioxide, pigments and surfactant.
	Reprosil A Regular (378204)		
Condensation Silicone (CS)	Perfil Putty (158/05)	Vigodent, Rio de Janeiro, Brazil	*Base: poly(dimethyl) siloxane, tetraethyl orthosilicate, colloidal silica or microsized metal oxide. Catalyst: stannous octoate, diluent's oil.*
	Perfil Light (016/05)		
	Oranwash L (27853)	Zhermack, Rovigo, Italy	
	Silon 2 APS Putty (1743-4)	Dentsply Latin America, Petrópolis, RJ, Brazil	Base: poly(dimethyl) siloxane, silica, pigments.
	Silon 2 APS Light (349629)		Catalyst: tetraethyl orthosilicate, silica, stannous dilaurate, pigments, mineral oil, paraffin.
	Xantopren VL Plus (210743)	Kerr Corporation, Orange, CA, USA	Similar to Perfil
	Optosil P Comfort (230363)		
	Speedex (Ig 205)	Coltène Whaledent, Germany	Base: poly(dimethyl) siloxane and quartz. Catalyst: stannous octoate, ethyl silicate, mineral oil.
Polyether (P)	Impregum Soft Medium Body (148408)	3M-ESPE, St. Paul, MN, USA	Polyether polymer, fatty acids triglycerides, dibenzyl toluene, c.i. pigment white, sulfonamide, polyethylene-polypropylene glycol, diatomaceous earth.
Alginate (ALG)	Jeltrate (156999)	Dentsply Latin America, Petrópolis, RJ, Brazil	Crystalline silica - cristobalite, crystalline silica - quartz, amorphous silica - diatomaceous earth, calcium sulfate, tetrasodium pyrophosphate, potassium alginate, magnesium oxide
	Jeltrate Plus (288721)		Similar to Jeltrate + quaternary ammonium compound, aspartame
	Jeltrate Chromatic Ortho (142603)		Similar to Jeltrate + chlorhexidine
	Hydrogum (21834)	Zhermack, Rovigo, Italy	*Potassium Alginate, Calcium Sulfate, Zinc oxide, potassium fluoride Diatomaceous Earth, sodium phosphate*
	Ezact Krom (078/08)	Vigodent, Rio de Janeiro, RJ, Brazil	Diatomaceous earth, calcium sulfate, tetrasodium pyrophosphate, potassium alginate, ZnO, Na fluoride

* Italicized components mean that composition was not provided by manufacturer and a general composition was obtained on Anusavice[2] (2003)

Figure 1- Impression materials used in the study

Table 1- Means and standard deviations (pixels) and results of statistical analysis of impression materials radiodensity (Kruskal-Wallis and Dunn's Method; p<0.05)

Groups	Mean (SD)	Mean Rank	Statistical Analysis by Kruskal Wallis and Dunn's Test (p<0.05) *
Permlastic Light	247.08 (2.68)	365.20	
Permlastic Regular	241.94 (4.77)	355.80	
Adsil Heavy Body	151.67 (3.8)	328.20	
Speedex	148.17 (3.73)	311.90	
Adsil Regular Body	146.40 (2.88)	301.53	
Silon 2APS Putty	143.56 (3.79)	278.30	
Perfil Putty	142.32 (4.47)	266.40	
Oranwash L	141.93 (4.3)	263.53	
Hydrogum	138.98(2.81)	235.47	
Xantopren VL Plus	138.32 (3.91)	227.83	
Adsil Light Body	136.70 (4.24)	210.10	
Virtual Extra Light Body	136.50 (3.51)	209.13	
Jeltrate Plus	139.09 (16.65)	201.97	
Express Light Body	131.40 (3.87)	153.13	
Ezact Krom	131.24 (3.66)	152.47	
Aquasil Light	130.58 (4.64)	146.40	
Silon 2APS Light	130.41 (4.82)	145.03	
Perfil Light	128.76 (6.61)	127.27	
Jeltrate Chromatic Ortho	126.85 (3.34)	108.23	
Jeltrate	124.07 (2.4)	79.87	
Aquasil Extra-Light	122.51 (1.96)	64.63	
Reprosil A Putty	121.61 (2.73)	55.97	
Optosil P Comfort	119.73 (4.94)	43.43	
Impregum Soft (Medium body)	119.29 (3.55)	37.80	
Reprosil A Regular	118.42 (3.53)	30.40	

* Mean Ranks not connected by the same line are statistically different (p<0.05).

standard deviations are presented only to facilitate the understanding. However, since data were not normally distributed, the sum of the ranks as obtained by the nonparametric analysis is also provided. The Kruskal-Wallis test showed a highly significant difference among the experimental groups (*p*<0.001). The Dunn's Test showed that Permlastic Light (PS) and Permlastic Regular (PS), Adsil Heavy Body (AS), Speedex (CS), Adsil Regular Body (AS), Silon 2APS Putty (CS), Perfil Putty (AS) and Oranwash L (CS) were the most radiopaque groups. Express Light Body (AS), Ezact Krom (ALG), Aquasil Light (AS), Silon 2APS Light (CS), Perfil Light (AS), Jeltrate Chromatic Ortho (ALG), Jeltrate (ALG), Aquasil Extra-Light (AS), Reprosil A Putty (AS), Optosil P Comfort (CS), Impregum Soft Medium Body (P) and Reprosil A Regular (AS) were the most radiolucent groups (Table 1). In general, heavy-body materials from the same brand presented higher radiodensity values than regular or light-body materials. Comparisons between tooth structures and impression materials showed that only Permlastic Light (PS) and Permlastic Regular (PS) were similar to human enamel, but there was no similarity with bovine enamel. Human dentin was similar to Adsil Heavy Body (AS), and bovine dentin was similar to almost all materials, with except for Permlastic Light (PS) and Permlastic Regular (PS) (Table 2).

Comparisons within each group of impression material did not show heavy-body addition silicon materials presenting significantly higher radiodensity (Figure 2) than lower viscosity ones. On the other hand, condensation silicon showed that heavy-body materials of the same brand presented higher degree of radiodensity than other materials' viscosities (Figure 3), except for the comparison between Optosil P Comfort and Xantopren VL Plus. Because of the smaller number of studied polysulfides and polyether, these

Table 2- Comparison of radiodensity (pixels) between tooth structures and impression materials by Kruskal Wallis and Dunn's Method (p<0.05)

Enamel		Dentin			
Human 203.19	**Bovine 195.93**	**Human 161.29**	**Bovine 154.44**	**Radiodensity**	**Materials**
*				247.08	Permlastic Light
*				241.94	Permlastic Regular
		*	*	151.67	Adsil Heavy Body
			*	148.17	Speedex
			*	146.40	Adsil Regular Body
			*	143.56	Silon 2APS Putty
			*	142.32	Perfil Putty
			*	141.93	Oranwash L
			*	139.09	Jeltrate Plus
			*	138.98	Hydrogum
			*	138.32	Xantopren VL Plus
			*	136.70	Adsil Light Body
			*	136.50	Virtual Extra Light Body
			*	131.40	Express Light Body
			*	131.24	Ezact Krom
			*	130.58	Aquasil Light
			*	130.41	Silon 2APS Light
			*	128.76	Perfil Light
			*	126.85	Jeltrate Chromatic Ortho
			*	124.07	Jeltrate
			*	122.51	Aquasil Extra-Light
			*	121.61	Reprosil A Putty
			*	119.73	Optosil P Comfort
			*	119.29	Impregum Soft (Medium body)
			*	118.42	Reprosil A Regular

* Groups marked with an asterisk are statistically similar to the respective tooth structure (p>0.05)

materials were compared to each other, showing higher radiodensity for the former (Figure 4). Regarding the alginate products, Hydrogum showed statistically significant higher radiodensity than the other alginates, but similar to Jeltrate plus (Figure 5). Figure 6 presents the comparison between the aluminum stepwedge and experimental groups, showing that Permlastic Light (PS) and Permlastic Regular (PS) presented degree of radiodensity comparable to thicker aluminum stepwedges, and Reprosil A Putty (AS), Optosil P Comfort (CS), Impregum Soft Medium Body (P) and Reprosil A Regular (AS) comparable to the thinnest aluminum stepwedge. Almost all remaining materials were similar to A2 and A3 aluminum stepwedges. Figure 8 shows the radiographic image of the groups and the aluminum stepwedge. SEM evaluation showed different filler types for each material (Figure 8), with some types of addition silicon showing remnants of polymer matrix not completely removed from fillers. Diatomaceous earth was found in Impregum Soft (Figure 8A), Reprosil A Regular (Figure 8E) and Jeltrate (Figure 8F). Perfil Putty (Figure 8C) showed bigger fillers than Perfil Light (Figure 8D), and Permelastic showed irregular filler particles (Figure 8B).

DISCUSSION

The accuracy and stability of dental impression materials is closely related to the filler volume fraction and type of matrix[7]. Heavy-body materials tend to present higher tear properties and tensile strength than light-body materials[18]. Similarly, it was expected that different compositions would render different degree of radiodensity, for the several studied dental impression materials. Generally, impression materials with high filler content show lower strain in compression and lower elastic recovery, due to the relatively lower presence of polymeric matrix[18]. Interestingly, some materials exhibit high elastic recovery and low strain in compression irrespective of the consistence type (light or heavy body materials)[18], which seems to be related to the type of polymer which composes materials matrix. However, as

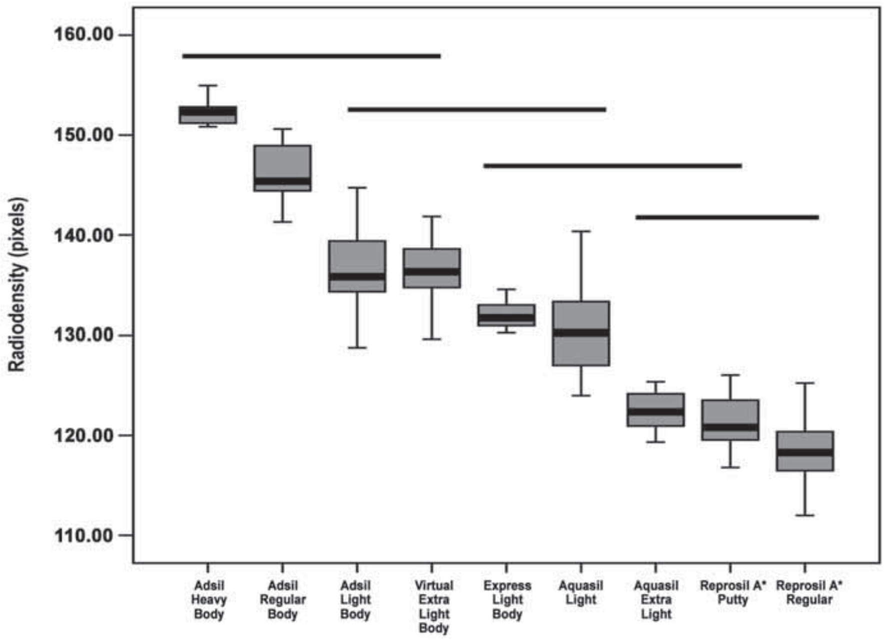


Figure 2- Comparison of radiodensity of addition silicon materials
Boxes not connected by the same line are statistically different by Kruskal Wallis and Dunn's Method (p<0.05)

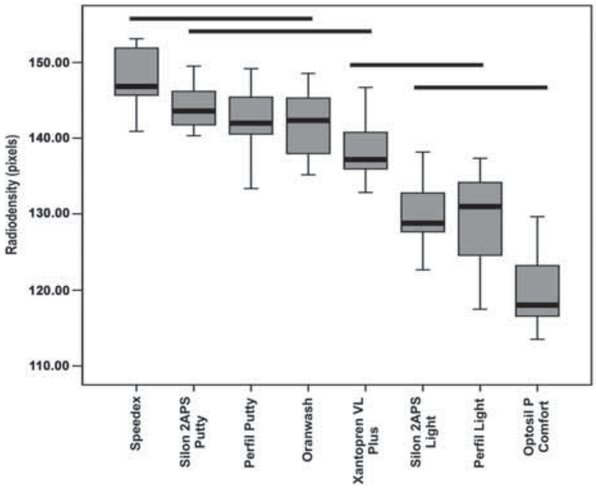


Figure 3- Comparison of radiodensity of condensation silicon materials
Boxes not connected by the same line are statistically different by Kruskal Wallis and Dunn's Method (p<0.05)

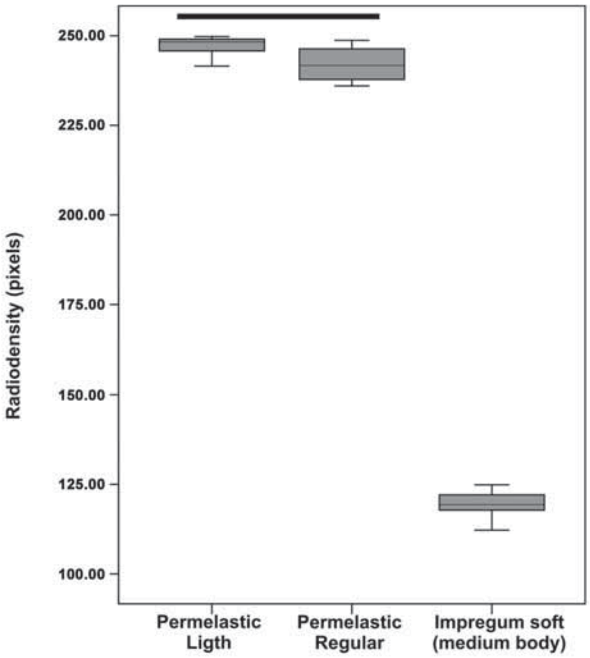


Figure 4- Comparison of radiodensity of polysulfide and polyether materials
Boxes not connected by the same line are statistically different by Kruskal Wallis and Dunn's Method (p<0.05)

observed by Fonseca, et al.[11] (2006), the polymeric fraction of dental materials is not responsible for increasing radiodensity values. The addition of chemical elements with high atomic numbers, such as lead, zinc, strontium, zirconium, barium and lanthanum, result in more radiopaque materials[3,27]. Materials with more radiopaque elements are more thus radiopaque. If the filler composition does not provide a radiopaque material, materials with good mechanical properties by high filler content or improved polymers will show themselves with low radiodensity, as observed in the present study.

Of all the classes of impression materials, polysulfides were the most radiopaque ones (Figure 7). Apparently, the reason for such a degree of radiodensity is the presence of lead dioxide in the composition, which acts as a catalyst of the setting reaction. Visually, it seems that it would be easy to detect these materials against a background of enamel or dentin. The same finding might not be true for radiolucent materials, such as polyethers, but further studies are necessary to prove this assumption. Careful attention must be paid for the analysis of Table 2 because the large number of studied materials can make different materials became statistically similar to each other[16]. Thus, the comparison within groups of materials seemed more interesting, and Table 2 can only illustrate that different materials with different composition show different radiodensity.

When considering the materials in separate groups, for the polysulfides, it was expected that the regular-body one would have higher radiodensity, but it did not occur, which proves that composition rather than filler content is more important for polysulfides (Figure 4). The studied polyether was already expected to present a low degree of radiodensity due to the absence of radiopaque fillers in its composition and also due to the reduced amount of filler content (manufacturer's information). The effect of filler content was more pronounced in the addition and condensation silicones, although within the same material brand, statistically significant differences where found just for condensation silicones (Figures 2 and 3). This occurrence means that for addition silicones, besides filler type and volume fraction, other factors are responsible for the observed results. Platinum and palladium seem to offer an important contribution to the observed radiodensity of these materials. Platinum salts are generally used as a catalyst for the setting reaction, and palladium is used for eliminating hydrogen release from the polymeric reaction. On the other hand, condensation silicon materials showed that heavy-body materials from the same commercial brand presented the highest degree of radiodensity (Figure 3), except for Optosil P Comfort and Xantopren VL Plus. Thus, for this group of materials, filler type and volume fraction seem to be the most important factor for radiodensity. Although Xantopren VL Plus is the light-body material for Optosil P Comfort, they probably present similar filler content, which could explain these findings. Condensation silicones have

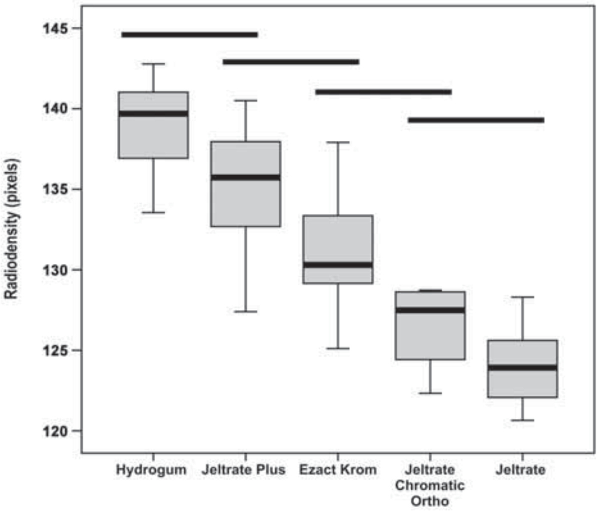


Figure 5- Comparison of radiodensity of alginate materials
Boxes not connected by the same line are statistically different by Kruskal Wallis and Dunn's Method (p<0.05)

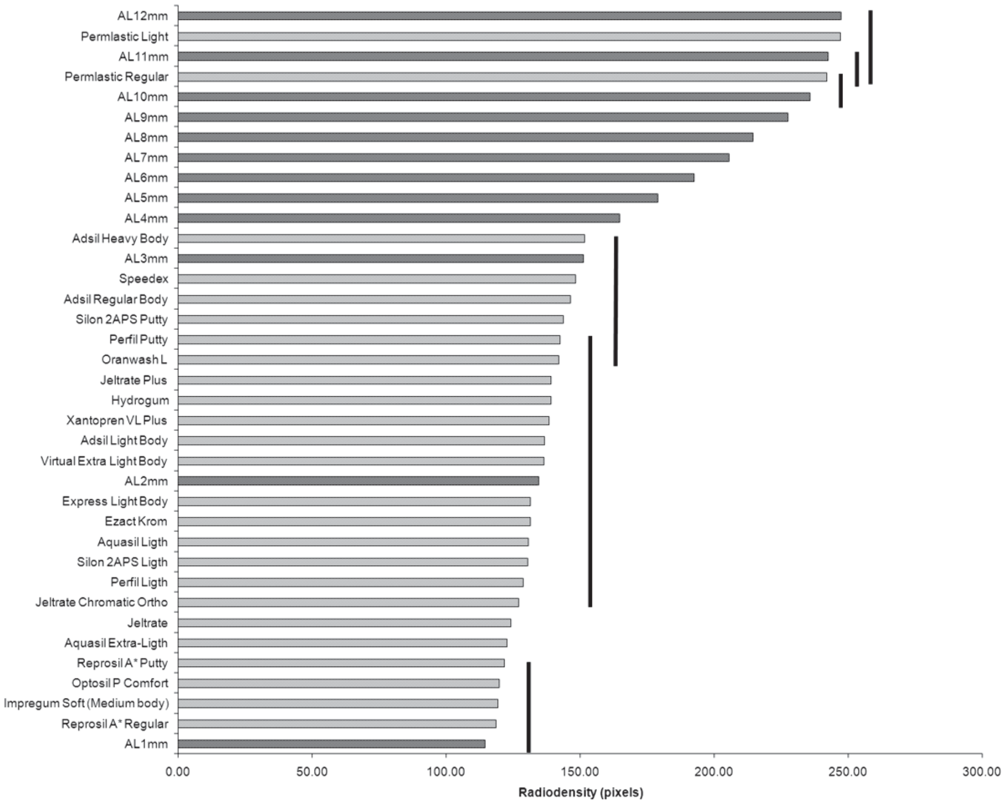


Figure 6- Comparison between materials and aluminum stepwedge
Bars not connected by the same line are statistically different by Kruskal Wallis and Dunn's Method (p<0.05)

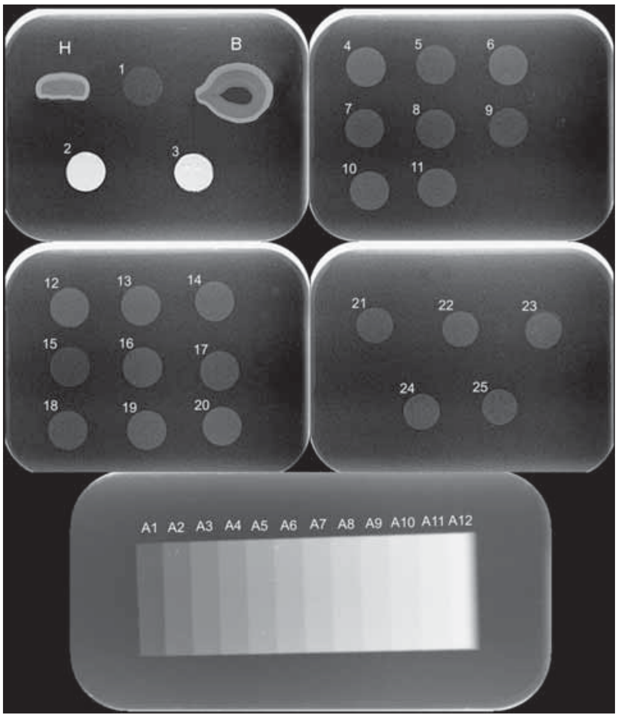


Figure 7- Digital radiographs of experimental groups and aluminum stepwedge. Impression materials: 1, Impregum Soft (Medium Body); 2, Permlastic Regular; 3, Permlastic Light; 4, Speedex; 5, Oranwash L; 6, Silon 2 APS Putty; 7, Silon 2 APS Light; 8, Xantopren VL Plus; 9, Optosil P Comfort; 10, Perfil Putty; 11, Perfil Light; 12, Adsil Heavy Body; 13, Adsil Regular Body; 14, Adsil Light Body; 15, Aquasil Extra-Light; 16, Aquasil Ligth; 17, Virtual Extra Light Body; 18, Reprosil A Regular; 19, Reprosil A Putty; 20, Express Light Body (Regular Set); 21, Jeltrate Plus; 22, Jeltrate Chromatic Ortho; 23, Jeltrate; 24, Ezact Krom; 25, Hydrogum. Aluminum stepwedge: A1, 1.0 mm; A2, 2.0 mm; A3, 3.0 mm; A4, 4.0 mm; A5, 5.0 mm; A6, 6.0 mm; A7, 7.0 mm; A8, 8.0 mm; A9, 9.0 mm; A10, 10.0 mm; A11, 11.0 mm; A12, 12.0 mm. Tooth Structures, H, human; B, bovine

tin oxides in their composition, which participates of the setting reaction, and could also be the reason for the observed radiodensity.

Alginate impression materials generally have a volumetric filler fraction composed by diatomaceous earth of around 80-90%[10], but this did not result in high radiodensity. Jeltrate, for example, was significantly more radiolucent than Hydrogum (Figure 5). Zinc oxide is usually found in these materials, which seem to be related to their radiodensity. However, the composition informed by manufacturers (Figure 1) barely explains these results. As stated before, the presence of chemical elements with high atomic number enables higher radiodensity. A pilot-study using dispersive x-ray analysis showed the presence of antimony in their composition, which is a metalloid with high atomic number present in higher proportion in Hydrogum and Jeltrate Plus, the most radiopaque alginates in this study. Thus, composition seems to be the most important factor for the radiodensity of alginates.

Although this is not an usual recommendation for impression materials, restorative materials need a slightly higher degree of radiopacity than that of enamel[14,15] in order to enable ideal clinical performance. Enamel and dentin from human and bovine teeth are reported to be similar to each other in radiodensity[13], but on this study it was rare to find impression materials that were at the same time similar to human and bovine enamel, or dentin (Table 2). It is likely that alterations in mineral deposition and microstructure[12] may be the reason for these findings. However, further research is necessary. Some studies have established the standard enamel radiodensity, based on a comparison with aluminum stepwedges[3,11,24], to be equivalent to 2- or 3-mm-thick aluminum. Among all studied materials, only Jeltrate (ALG), Aquasil Extra-Light (AS), Reprosil A Putty (AS), Optosil P Comfort (CS), Impregum Soft Medium Body (P) and Reprosil A Regular (AS) presented a degree of radiodensity lower than 2 mm aluminum, which would virtually eliminate the possibility of detection against a background of enamel or dentin in a conventional periapical x-ray examination. However, if we consider results from Table 2, only both Permelastic viscosities were similar to human enamel and Adsil Heavy body to human dentin, which would virtually eliminate all other materials from an easier radiographic detection against hard tooth structures. Figure 8 shows fillers found in some materials. Interestingly, both Reprosil viscosities and Impregum Soft (materials with the lowest radiodensity) have diatomaceous earth in composition (not stated by Reprosil manufacturer), which appears not to contribute to high radiodensity levels, similarly to what happened in alginates. As the use of radiopaque impression materials aims instant and clear material radiographic detection, the higher the radiodensity, the easier the visualization. In this situation, polysulfides presented the best behavior, being comparable to 10-, 11- and 12-mm-thick aluminum.

Table 2 showed that human and bovine tooth structures did not have the same behavior when compared to impression materials. In spite of the fact that on a previous study human and bovine enamel and dentin were considered similar in radiodensity[13], it was not possible to establish similarity between human and bovine tooth structures with the same materials; thus, the use of bovine teeth showed limited results.

The use of radiopaque impression materials seems important for the detection of materials in the oral environment. According to Chen, et al.[6] (2002), even a 10-min exposure of human gingival fibroblast cells to various impression materials had a cytotoxic effect. Manufacturers should be stimulated to produce materials with an adequate level of radiodensity, as demonstrated in the present study.

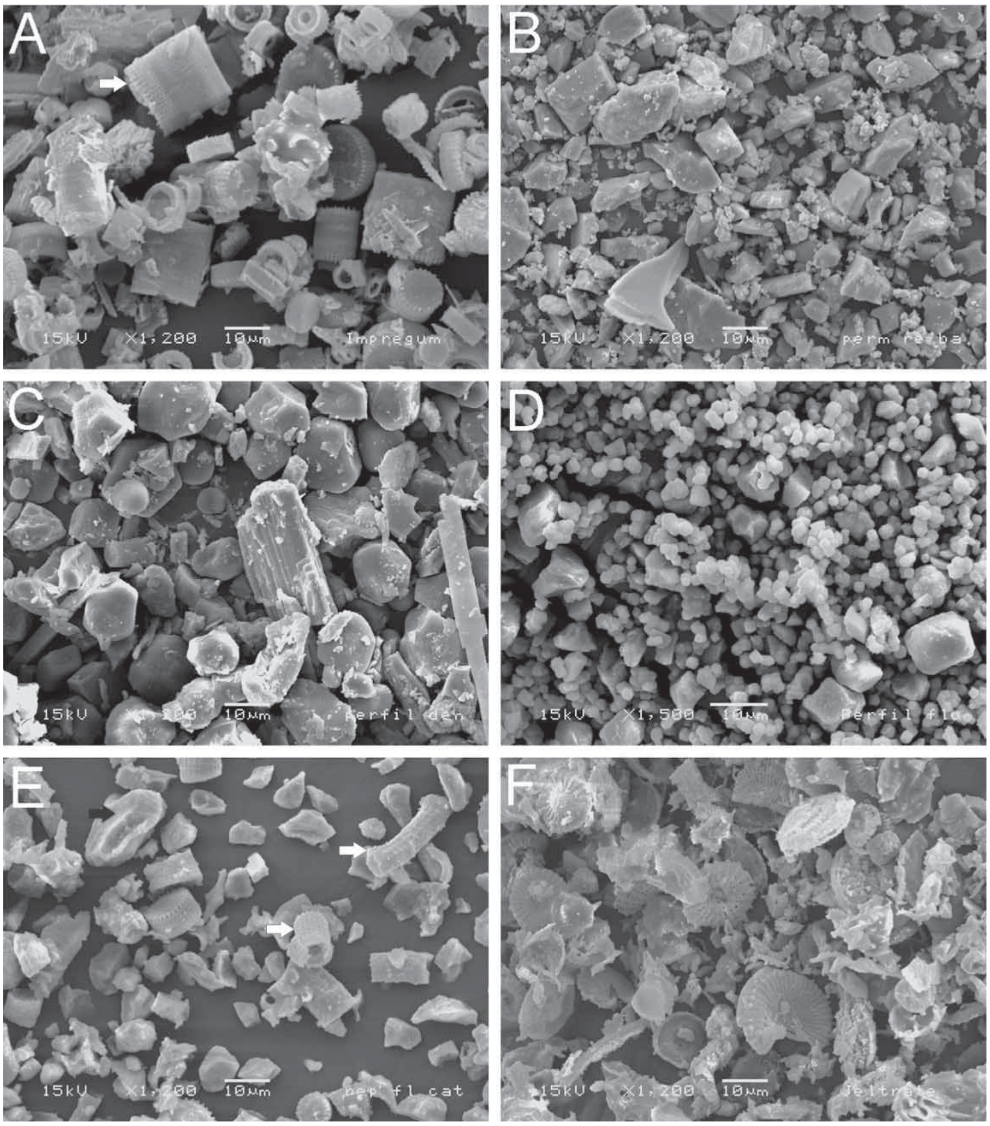


Figure 8- SEM images of impression materials fillers. A, diatomaceous earth fillers of Impregum Soft (P) showing a rounded structure (white arrow); B, irregular fillers of Permlastic Regular (PS); C and D, fillers of Perfil Putty (CS) and Perfil Light (CS), respectively, showing the increased size of fillers of the heavy-body material; E, fillers of Reprosil A Regular (AS) showing the presence of diatomaceous earth (white arrow) and inorganic fillers (black arrow); F, diatomaceous earth in Jeltrate (ALG)

CONCLUSIONS

It was found that different impression materials showed different degrees of radiodensity and the reasons were related to their composition. Filler type and volume fraction, and the presence of radiopaque chemical elements are suggested as the main characteristics that render different radiodensity. Limitations of the present study, such as the need for specific research on materials' composition, must be overcome in order to confirm these assumptions. Only Permlastic viscosities had similar radiodensity to that of human enamel and Adsil Heavy Body to human dentin, enabling easier radiographic detection against hard tooth structures.

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