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Effects of radio-opacifier addition in dental impression material

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ABSTRACT

Objective: The aim of this *in vitro* study was to determine the effects of barium sulfate addition in two dental impression materials previously proved as radiolucent.
Materials and Methods: An irreversible hydrocolloid (IH) and polyether (PE) were tested for optical density, linear dimension stability and detail reproduction.
Statistical Analysis Used: The optical density data were submitted to Kolmogorov-Smirnov normality test and compared with two-way ANOVA and Tukey (alpha=0.05).
Results: The results of optical density (pixel) were: IH control 45.24^{f} (± 7.6), PE control 54.93^{e} (± 4.45), PE 5Wt% 60.43^{d} (± 6.27), IH 1Wt% 61.54^{cd} (± 5.3), PE 1Wt% 66.9^{bc} (± 5.05), IH 5Wt% 67.17^{b} (± 6.01), PE 10Wt% 84.55^{a} (± 5.14), IH 10Wt% 85.33^{a} (± 5.53). On detail reproduction, polyether control was able to copy the 6 μm line. Adding 1 or 5Wt% of barium sulfate have not change this characteristic. For the irreversible hydrocolloid, the control group was able to copy a line with 14 μm, however, adding 1Wt% barium sulfate, the capability decreased to 22 μm. Adding barium sulfate in the polyether promoted an increase in between the copied lines, for the control, the average distance was 931.6 μm, 936 μm to 1Wt% and 954.5 μm to 5 Wt%. For the IH, the control presented 975 μm in comparison to 987.25 μm for 1 Wt% samples.
Conclusion: The addition of barium sulfate was capable of increasing significantly the optical density of tested material, have changed the linear dimension stability, however, have not interfered in detail reproduction only for PE.

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Key words: Barium sulfate, impression materials, linear dimension stability and detail reproduction, optical density

In most areas of dentistry, taking impression is a very important step that can determine the success of work. Nevertheless, this usual practice can cause some complications such as impression material retention in the gingival sulcus or aspiration.[1,2] Reporting cases describes the effects of impression material retention in the subgingival area like irritation, inflammation, suppuration, periodontal abscess and pyogenic granuloma.[3-5] The inhaled material can have several respiratory consequences, mainly recurrent pneumonia, which requires bronchoscopy or even surgical interventions.[6,7] In these cases, to localize the materials is necessary radiographic exam and the high optical density is requirable to give a correct diagnosis.[1,2]

The irreversible hydrocolloid and elastomers are the most clinically used impression material in the oral rehabilitation. In a previous research work,[12] the authors concluded that polieter and irreversible hydrocolloid were the most radiolucent impression material, polysulfide and some polyvinyl siloxane showed the highest optical density or radio opacity.[8-11,13]

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Parissis *et al*. showed the possibility to change chemically radiolucent impression material to help in radiographic detection,[11] however, no other *in vitro* study was carried on to verify the effect of this adding in such materials. Therefore, the aim of this *in vitro* study was to determinate the effects of adding barium sulfate in two dental impression materials, an irreversible hydrocolloid (IH, Jeltrate type II, Dentsply, Petrópolis, RJ, Brazil) and polyether (PE, Impregum Soft, 3M/ESPE, St. Paul, MN, USA), that were tested for optical density, linear dimension stability and detail reproduction.

MATERIALS AND METHODS

The material used in this study is showed in the Table 1.

Table 1: Description of materials used in the test

Material	Classification	Manufacturer	Batch number
Impregum soft PE	Polyether	3M/ESPE, St. Paul, MN, USA	215402
Jeltrate type II IH	Irreversible hydrocolloid	Dentsply, Petrópolis, RJ, Brazil	23589 484278
Barium sulfate 100%	Radiological contrast	Cristália, Itapira, SP, Brazil	05064876

To define the optical density, eight groups [Table 2] were established according to the material (IH or PE) and the amount of barium sulfate (control, one, five or 10 Wt%). For each material, 10 samples (3 mm thickness and 6 mm diameter) were made using a PTFE mould. Two control groups and other six with addition of 1 Wt%, 5 Wt% and 10 Wt% barium sulfate were established. After the setting time, the sample was measured using a digital caliper (Mitutoyo, Suzano, SP, Brazil). The material was handled according to the manufacturer's specification.

The polyether was handled using a glass plate and spatula number 24 (SS White, Rio de Janeiro, RJ, Brasil) and poured into the mould using a specific syringe for elastomers. The irreversible hydrocolloid was manipulated in a flexible bowl with a flexible plastic spatula for one minute. The amount of barium sulfate was established with an analytical balance (AG 204, Mettler Toledo, Switzerland).

After the setting time, the sample was mounted on number two optical plates of digital system Digora (Soredex, Orion Corp., Helsinki, Finland). The standardization of digital images defined following specific criteria: X-ray device Timex-70 DRS (Gnatus, Ribeirão Preto, SP, Brazil), with 70 kVp and 7 mA; maintenance of focal distance in 40 cm, central beam focusing 90° with the center of optical plate; time exposure of 0.2 s. For comparative purposes, the optical density of one aluminum stepwedge with 3 mm thickness was verified under the same conditions of samples.

The images were digitalized with Digora System. To evaluate the optical density, two areas (20 × 20 *pixels*) were selected in opposite sides in each digital image, totaling 160 readings

To determine the linear dimension stability and detail reproduction, a metallic standardized model was used with lines of 40, 32, 27, 22, 14, 9, 6 e 3μm respectively. Only groups with significant differences on optical density were tested, i.e., IH control and 1Wt% and PE control, 1Wt% and 5 Wt% of barium sulfate.

The samples of IH control and IH 1 Wt% were copied with polyether because of the possibility of syneresis after the setting time. Each sample was reproduced with epoxy resin, gold sputter coated and submitted to an examination with scanning electron microscope (SEM). This test is a

Table 2: Groups description and relative proportions

Groups (%)	Materials (%)
IH control	Jeltrate type II
PE control	Impregum soft
IH 1 Wt	Jeltrate type II with 1 Wt of barium sulfate
IH 5 Wt	Jeltrate type II with 5 Wt of barium sulfate
IH 10 Wt	Jeltrate type II with 10 Wt of barium sulfate
PE 1 Wt	Impregum soft with 1 Wt of barium sulfate
PE 5 Wt	Impregum soft with 5 Wt of barium sulfate
PE 10 Wt	Impregum soft with 10 Wt of barium sulfate

modification of ADA number 18 specification. The detail reproduction was recorded in the narrowest continue line seen and the distance between the first (40 μm) and third (27 μm) lines to determine the linear dimension stability.

Statistical analysis

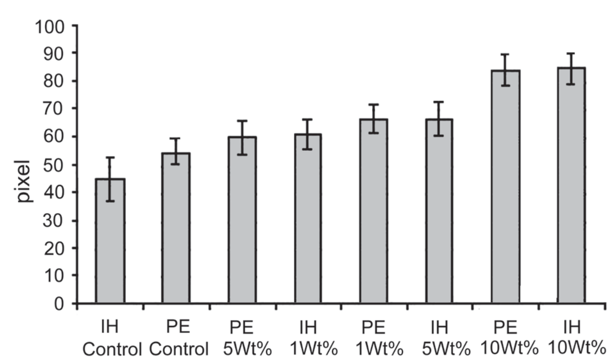
The optical density data were submitted to Kolmogorov-Smirnov normality test and compared with two-way ANOVA and Tukey (α= to 0.05).

RESULTS

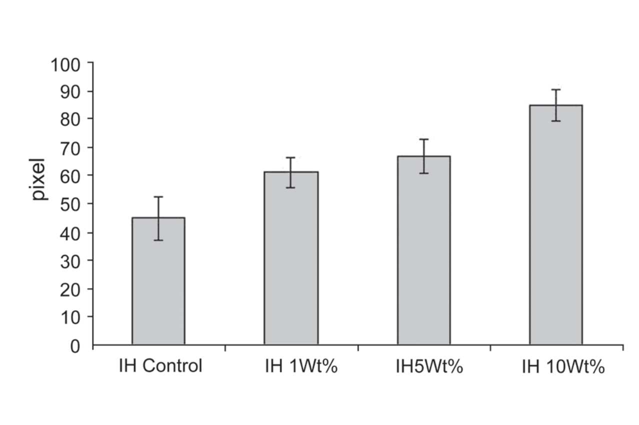
Significant differences ($P < 0.05$) were observed between the evaluated material and the amount of barium sulfate. The addition of barium sulfate was capable to increase significantly the optical density of tested materials ($P < 0.05$). The results of optical density (*pixel*) were: IH control 45.24[f] (± 7.6), PE control 54.93[e] (± 4.45), PE 5 Wt% 60.43[d] (± 6.27), IH 1 Wt% 61.54[cd] (± 5.3), PE 1 Wt% 66.9[bc] (± 5.05), IH 5 Wt% 67.17[b] (± 6.01), PE 10 Wt% 84.55[a] (± 5.14), IH 10 Wt% 85.33[a] (± 5.53) [Graph 1].

Significant differences were recorded for optical density ($P < 0.05$) when barium sulfate was inserted in irreversible hydrocolloid [Graph 2]. The increasing amount of radiopacifier induced a higher optical density of this material. To the polyether, significant differences were recorded to the optical density test. However, when 5 Wt% of barium sulfate was added, a significant decrease was recorded compared to 1 and 10 Wt% groups [Graph 3].

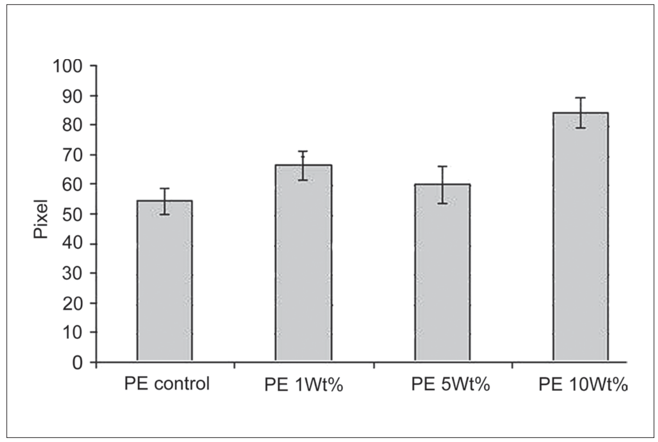
For detailed reproduction, polyether control was capable to copy the 6μm line. Adding one or five Wt% of barium sulfate was not able to change this behavior [Figure 1a-c]. For the irreversible hydrocolloid, the control group copied the line with 14 μm, however, adding one Wt% barium sulfate, the capability decreased to 22 μm [Figure 2a and b]. Adding barium sulfate in the polyether promoted an increase between the distance of copied lines [Figure 3a-c]. For the PE control, the average distance was



Graph 1: Comparison of optical density averages



Graph 2: Comparative optical density chart of irreversible hydrocolloid groups.



Graph 3: Comparative optical density chart of polyether groups

931.6 μm, 936 μm to 1 Wt% and 954.5 μm to 5 Wt%. For the IH, the control group presented 975 μm in comparison to 987.25 μm for 1 Wt% samples [Figure 4a and b].

DISCUSSION

On clinical use of impression material there is seven per cent possibility of intra-sulcular retention when the impression is taken.[1] Several authors have evidenced the difficulty of radiological detection of impression materials.[1,2,11-13] Clinical reports have described the effects of retention of impression materials in the subgingival region, such as: Irritation, inflammation, suppuration, periodontal abscess and pyogenic granuloma.[2,13-15] Histological analysis of impression material toxicity showed the irreversible hydrocolloid as the most inflammatory potential, presenting acute abscess and total destruction of the tissue next to the epithelium. Inflammatory response to silicones and polyether was less intense than the irreversible hydrocolloid and polysulphides.[2,17]

In this study, adding barium sulfate in impression materials was capable to increase significantly the optical density of tested materials ($P < 0.05$), in according to the results obtained on the literature.[13] Only one difference, however, was observed in the group PE five Wt%, that presented statistically by less optical density than the PE one Wt%. This probably has happened due to hydrophilic behavior of this material since water was used as vehicle in barium sulfate contrast.

The low optical density recorded for control groups was already expected as observed in the results of other tests.[2,3,11,16] Based on the optical density of 133.58 pixels for three mm thickness of the stepwedge used as reference, the values obtained to the control groups reached 33.87% to the irreversible hydrocolloid and 41.12% to the polyether. The higher amount of barium sulfate increased significantly the optical density of the impression materials ($P < 0.05$). Both materials achieved 63% of optical density from stepwedge when adding 10 Wt% of barium sulfate.

However, other properties must be evaluated besides the radiographic characteristic, as well as mechanical behavior and clinical applications. The irreversible hydrocolloids are the most clinically used impression materials, nevertheless, it has low mechanical behavior, low tear energy, tensile strength and higher flow rate.[6,18] These characteristics associated to the use of custom trays enlarge the risk of tearing and associated to the low optical density in small thickness may difficult the localization and result in intense inflammatory response.[11,14] Thus, it requires more caution in the manipulation.

The polyether is considered as a rigid material and is difficult to be removed from retentive areas. This material shows higher tear energy than polydimethylsiloxane and polyvinylsiloxane silicones and lower than the polysulphides.[8] As the polyether is less toxic than the polysulfide, if intrasulcular retention occurs, difficulty of localization might be expected.[19] Morever, this hydrophilic material is more suitable to flow into the gingival sulcus.

On linear dimensional stability and detail reproduction, only groups with significant differences on optical density were tested, i.e., IH control and one Wt% and PE control, one Wt% and five Wt% of barium sulfate. On detail reproduction, polyether control was able to copy the 6 μm line. Adding one or five Wt% of barium sulfate have not changed this characteristic. For ISO Standard 4823, the polyether must copy 20 μm. This value is superior to that recorded in the present study.[20] The addition of barium sulfate in the polyether promoted an increase in distances between the copied lines. For control group, the average was 931.6 μm, 936 μm to one Wt% and 954.5 μm to five Wt%. This radio-opacifier also has not interfered on the detail

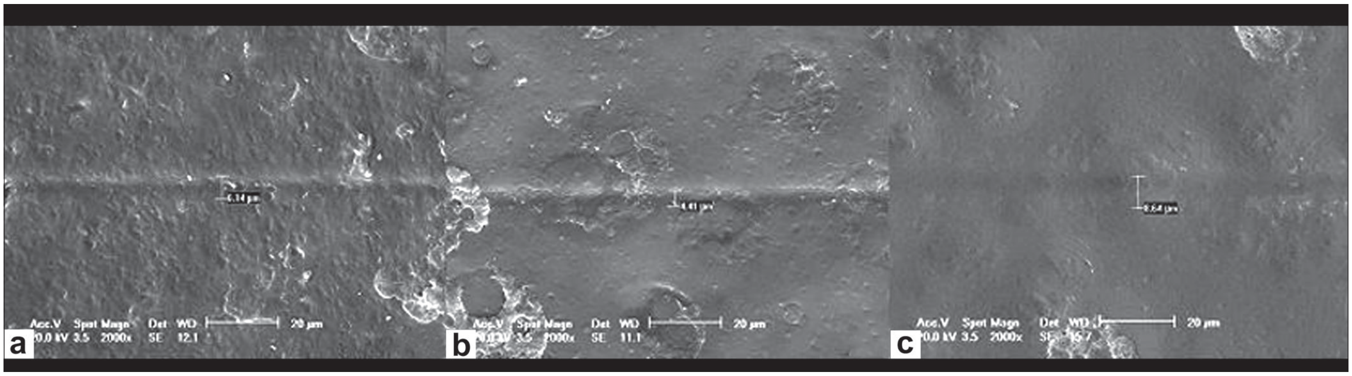


Figure 1: Comparison between detail reproduction of (a) polyether control, (b) 1 Wt% and (c) 5 Wt%

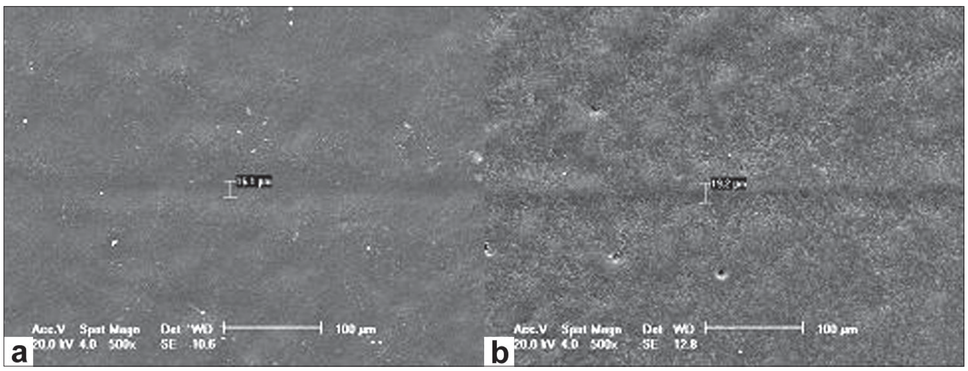


Figure 2: Comparison between detail reproduction of irreversible (a) hydrocolloid control and (b) 1 Wt%

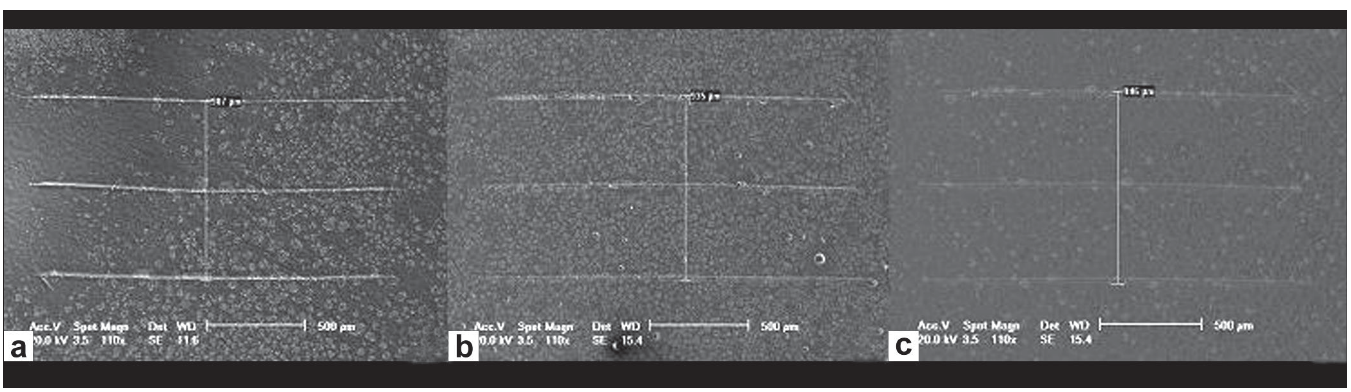


Figure 3: Comparison between dimensional stability of (a) polyether control, (b) 1 Wt% and (c) 5 Wt%

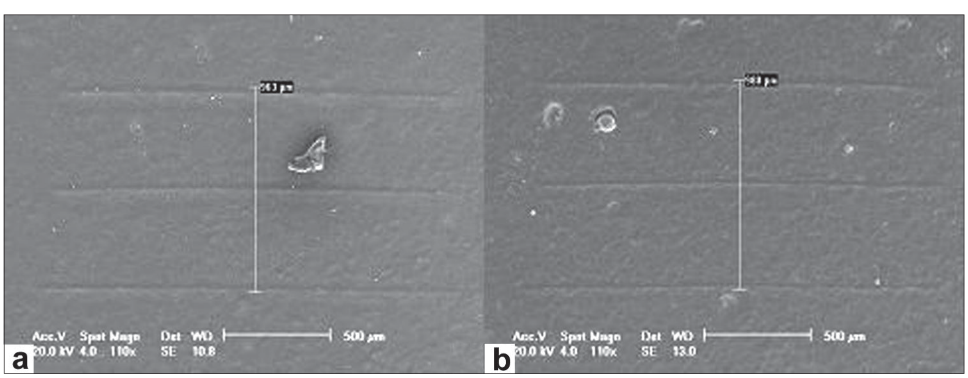


Figure 4: Comparison between dimensional stability of (a) irreversible hydrocolloid control and (b) 1 Wt%

reproduction of polyether, however, have altered the linear dimensional stability on 0.004% with addition 1Wt% and 0.023% to 5Wt%. For the irreversible hydrocolloid, the control group was able to copy a line with 14 μm thickness, however, adding one Wt% barium sulfate, the capability decreased to 22 μm. The irreversible hydrocolloid, according to ADA #18 specification, must reproduce a line of 0.075 mm (75 μm) thickness.[21] The IH control group was able to reproduce the line of 14 μm when analyzed in SEM. Adding of 1 Wt% barium sulfate there was a decrease on the capability of detail reproduction, undergoing to a line of 22 μm. This thickness is still in accordance to the ADA requirement, with large safety margin. For the IH, the control groups presented 975 μm in comparison to 987.25 μm for 1Wt% samples. In irreversible hydrocolloid, the addition of barium sulfate decreases the capability of detail reproduction and has altered linear dimensional stability in 0.012%.

We suggest more research of mechanical behavior to evaluate the radio-opacifier addition on tensile strength and tear energy of impression. Additional data will provide subsidize to further clinical studies. These additional tests shall verify the viability of using more safe impression material.

CONCLUSION

The low optical density in the impression material tested in this study may be partially solved. Additon of barium sulfate was capable to increase significantly the optical density of material ($P < 0.05$), except for PE five Wt%. The linear dimension stability has changed in all tested groups. The radio-opacifier has changed the detail reproduction of irreversible hydrocolloid and have not interfered with the polyether groups, however, all groups respected the requirements of international specifications.

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