Original Article

Radiopacity of impression materials using an indirect digital system

Radiopacidade de materiais de moldagem usando um sistema digital indireto

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Abstract

Purpose: This *in vitro* study evaluated the radiopacity of impression materials using an indirect digital system.

Methods: Samples of four polyvinyl siloxanes, one polyether, one polysulfide, and one irreversible hydrocolloid were fabricated with 1.0, 1.5, and 3.5mm-thickness. Three samples of different thickness were placed on the Digora optical plate and exposed. The optical density (*pixels*) was recorded in three areas resulting in a total of 360 measurements. Data were analyzed by 2-way ANOVA and Tukey tests (α=0.05).

Results: Significant differences were observed among all materials and thicknesses tested (P<0.001). Irreversible hydrocolloid and polyether showed the lowest optical density. Polysulfide showed the highest optical density under all evaluated conditions.

Conclusion: There was a significant difference in optical density for all impression materials tested. Composition changes are suggested to allow radiographic detection and improve safety during clinical use of impression materials.

Key words: Optical density; digital dental radiography; dental impression materials

Resumo

Objetivo: Este estudo *in vitro* comparou a radiopacidade de materiais de moldagem usando um método radiográfico digital indireto.

Metodologia: Amostras de quatro polivinil-siloxanos, um poliéter, um polissulfeto e um hidrocolóide irreversível foram confeccionadas com alturas de 1, 1,5 e 3,5mm. Três amostras das diferentes espessuras foram dispostas sobre uma placa óptica Digora e exposta. A densidade óptica (*pixels*) foi registrada em três diferentes áreas de cada amostra. Os dados foram analisados pelo teste de análise de variância de dois fatores e teste de Tukey (α=0,05).

Resultados: Diferenças significantes foram observadas entre todos os materiais e espessuras testadas (P<0,001). O hidrocolóide irreversível e o poliéter apresentaram a menor densidade óptica. O polissulfeto apresentou a maior densidade óptica em todas as condições avaliadas.

Conclusão: Há diferença significativa na densidade óptica dos materiais de moldagem avaliados. Alterações na composição são necessárias para facilitar a detecção destes materiais a fim de aumentar a segurança no uso clínico.

Palavras-chave: Densidade óptica; radiografia dentária digital; materiais para moldagem odontológica

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Introduction

Irreversible hydrocolloids (alginates) and elastomers are the elastic impression materials most commonly used in oral rehabilitation (1). The literature reports cases of material retention in the gingival sulcus or the possibility of aspiration in 7% of all impressions made (2-5). The inhaled materials could have several respiratory consequences, usually recurrent pneumonia, which requires bronchoscopy or even surgical interventions (6,7). Clinical reviews describe the effects of impression material retention in the subgingival area, such as: irritation, inflammation, suppuration, periodontal abscess, and pyogenic granuloma (8-11). Histologic analysis of impression material toxicity showed that polyether and silicone-based materials induced lower inflammatory responses than those with alginate and polysulfide (12,13). Irreversible hydrocolloids are the most aggressive, resulting in acute abscess and total destruction of the tissue close to the epithelium. However, clinical and radiographic detection of irreversible hycrocolloids may be difficult due to their low optical density (13). Polysulfide can also induce abscesses and mild tissue response. Polysulfide with PbO_2 was shown to be histologically more aggressive and more radiopaque.

Previous studies compared the radiopacity of impression materials with an aluminum step-wedge (14-18), however this evaluation method has gradually been replaced by digital systems that reduce error and offer several resources for image editing (19). Comparative studies between digital systems have indicated that evaluation of optical density using Digora (Soredex, Orion Corp., Helsinki, Finland) result in less standard deviation and more precise values (20-22). However, up to date, scarce data are available regarding optical density evaluation of impression materials using digital systems. Therefore, this *in vitro* study aimed to evaluate and compare the radiopacity of impression materials using an indirect digital system.

Methods

The impression materials tested in this study are listed in Table 1. A two-piece metal mould, with 1.0, 1.5, and 3.5mm-thickness and 10mm inner diameter was used to prepare four samples of each material. All materials were mixed and handled in accordance with each manufacturer's instructions.

After final setting time, four groups with three samples of each material, one sample per thickness, were obtained. The samples were measured with a digital caliper (Mitutoyo Digimatic Caliper, Suzano, SP, Brazil) and placed under the Digora system optical plate number 2 (Soredex, Orion Corp., Helsinki, Finland). These samples were mounted following a standardized location: the 3.5mm- and 1.5mm-thick samples were placed at the top left and right sides, respectively, and the 1mm-thick sample was placed at the bottom part of the optical plate.

Digital images were obtained with a Timex-70 DRS X-ray unit (Gnatus, Ribeirão Preto, SP, Brazil), with a 70kVp and 7mA electrical regimen. The focal distance was fixed at 40cm, the central beam incidence was at 90º to the optical plates, and the samples were x-ray exposed for 0.20s.

The images were captured with the Digora indirect digital system. The optical density (pixels) was registered in three areas of 20x20 pixels in the 4-, 8-, and 12-hour positions (Fig. 1) in the same sample, comprising a total of 360 measurements. Data were analyzed by Kolmogorov-Smirnov normality test (α=0.01), two-way ANOVA, and Tukey HSD test (α=0.05).

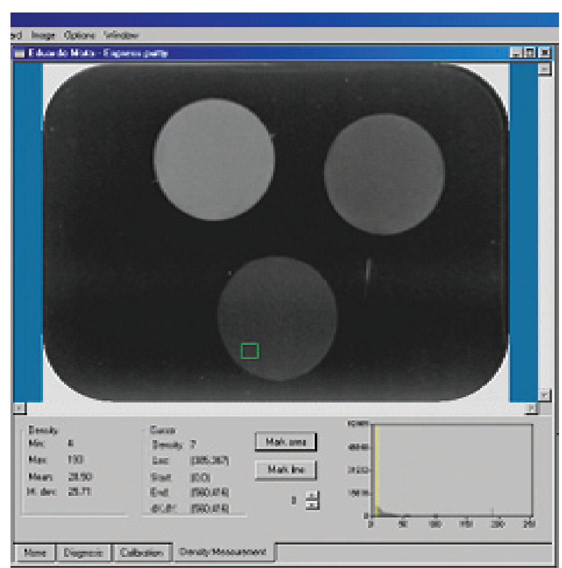


Fig. 1. Evaluation of the optical density of one 1.0mm-thick sample in a 20x20 pixels area using the Digora system.

Table 1. Characteristics of the impression materials tested.

Classification	Material	Manufacturer
Polyvinyl siloxane	Adsil Regular	Vigodent, Bonsucesso, RJ, Brazil
Polyvinyl siloxane	Contrast Light Regular and Medium	Voco, Cuxhaven, Germany
Polyvinyl siloxane	Express Putty and Light	3M/ESPE, St. Paul, MN, USA
Polyether	Impregum Soft	3M/ESPE, St. Paul, MN, USA
Polyvinyl siloxane	Imprint II Heavy and Light	3M/ESPE, St. Paul, MN, USA
Irreversible hydrocolloid	Jeltrate type II	Dentsply, Petrópolis, RJ, Brazil
Polysulfide	Permlastic Regular	Kerr Corp., Orange, CA, USA

Results

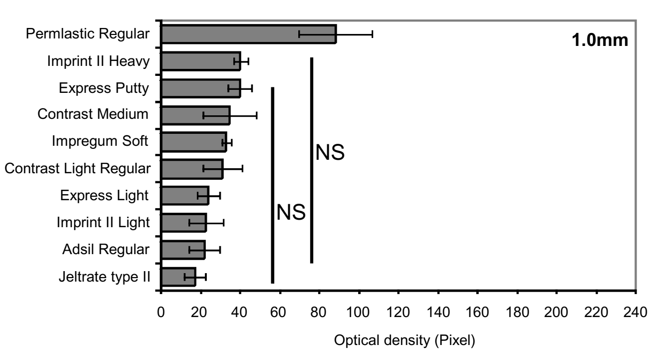
Table 2 displays the mean values of optical density for all impression materials within each thickness tested. Significant differences (P<0.001) were recorded among all materials and thickness evaluated. For 1.0mm-thick samples, Jeltrate showed the lowest optical density, and the highest density was recorded for Permlastic Regular; Express Putty and Imprint II Heavy mean values were higher than those for Jeltrate (Fig. 2).

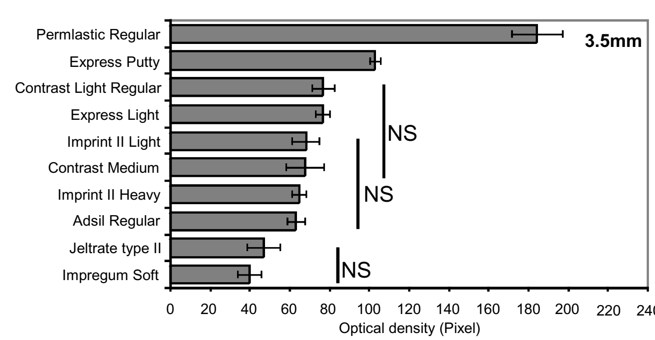
For 1.5mm-thick specimens, the minimum density was recorded for Jeltrate and the highest density for Permlastic Regular. The values for Imprint II Light and Heavy, Adsil Regular, Contrast Light Regular and Medium, and Express Light were not statistically different from Jeltrate. Impregum Soft and Express Putty mean values were statistically similar and higher than those for Jeltrate (Fig. 2).

For 3.5mm-thick samples, mean optical density values ranged from 39.90 pixels for Impregum Soft to 184.27 for Permlastic Regular. Impregum Soft and Jeltrate showed the lowest mean values followed by Adsil Regular, Imprint II Light and Heavy, and Contrast Medium. Mean values for Imprint II Light, Express Light and Contrast Light Regular were not statistically different. Express Putty and Permlastic Regular showed the highest mean values (Fig. 2).

Table 2. Optical density (mean and standard deviation, in pixels) of the tested impression materials for 1.0mm-, 1.5mm-, and 3.5mm-thickness.

Material	1.0mm		1.5mm		3.5mm	
	Mean	SD	Mean	SD	Mean	SD
Adsil Regular	21.85	7.86	32.20	12.19	63.06	4.42
Contrast Light Regular	31.18	9.71	43.61	10.14	76.79	5.39
Contrast Medium	34.80	13.33	34.64	6.29	67.52	9.62
Express Light	24.06	5.73	39.10	5.84	76.78	3.60
Express Putty	39.88	5.73	56.95	5.03	102.75	2.67
Impregum Soft	33.06	2.40	55.36	6.05	39.91	5.97
Imprint II Heavy	40.22	3.58	32.08	10.02	64.54	3.70
Imprint II Light	22.82	8.40	37.43	6.85	68.18	6.84
Jeltrate type II	17.27	5.54	25.08	8.51	46.64	8.35
Permlastic Regular	88.18	18.71	122.24	23.00	184.27	12.60





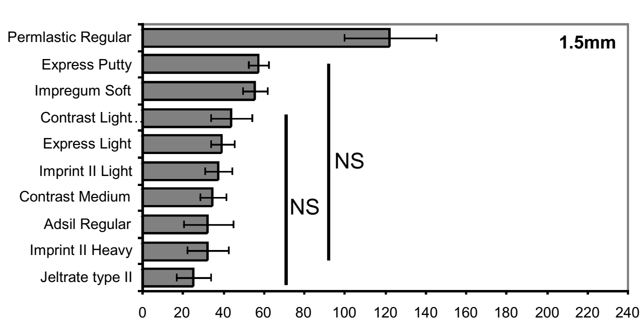


Fig. 2. Comparison of optical density mean values of the tested impression materials with 1.0mm-, 1.5mm-, and 3.5mm-thickness. Vertical bars connect means that are not statistically different (P>0.05).

Discussion

Radiopacity of elastic impression materials is a physical property rarely discussed in the literature (14-18). The possibility of tearing and retention inside the gingival sulcus (2,8,9,11), and aspiration (4) of these materials was described previously. Dental procedures are the main cause of foreign body aspiration (3,5), and oral rehabilitation therapy has been cited as being ranked first to cause incidents in Dentistry (23). Therefore, radiographic detection is imperative for diagnosing and identifying these materials. Nevertheless, only 22.6% of all radiographic examinations are performed for this purpose (5). Direct and indirect digital systems have been successfully used to detect optical density differences among composites (24) and glass ionomer cements (25) within different thickness and may be used for impression materials as well.

The present study showed significant differences in optical density among the evaluated materials and thickness using the Digora system. The lowest mean value was recorded for 1.0mm-thick Jeltrate (17.27 pixels), and the highest (184.27 pixels) for 3.5mm-thick Permlastic Regular, compared with a scale from 0 (radiolucent) to 255 (radiopaque). The low radiopacity shown by Jeltrate and Impregum Soft were comparable to previous findings (14,18). The high radiopacity of Permlastic Regular was shown before (12); this can be explained by the PbO_2 used as a catalyst, which also allows detection in 95% of polysulfide x-ray images (17).

However, besides desirable radiographic features, impression materials should comply with other factors, such as mechanical properties and clinical applications. Irreversible hydrocolloids are the elastic materials most commonly used in the dental clinics, but present poor mechanical behavior, such as low tear and tensile strength, and high flow rate (1,22). These properties associated with the use of stock trays that increase the risk of material tearing, the low radiopacity, and the intense inflammatory response (13), demand caution during manipulation and clinical use.

The addition cured silicones (polyvinylsiloxanes) tested showed similar optical density, with the exception of the putty consistency of 1.0mm- and 1.5mm-thick samples; however, the optical density was lower than that of the polysulfide. Because addition cured silicone has more cohesive polymers, the risk of tearing is minimized during mould removal in a clinical situation (22).

The direct visualization of the foreign body in a chest radiograph depends on factors that affect the penetration of X-rays (material thickness, size, specific weight, atomic weight) (5). Therefore, further studies are necessary to test the addition of an inert agent, such as barium sulfide (17), in the composition of impression materials to increase the material radiopacity.

Conclusion

Radiopacity varied as a function of impression material and thickness. Jeltrate and Impregum Soft showed the lowest mean optical density values at different thickness. Permlastic Regular showed the highest radiopacity among all the materials. Possible difficulties in X-ray identification might be expected for irreversible hydrocolloid, polyether, and addition cured silicones. Composition changes are suggested to allow radiographic detection of impression material residues and improve safety during clinical use.

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