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# Surface Detail Reproduction and Dimensional Accuracy of Stone Models: Influence of Disinfectant Solutions and Alginate Impression Materials

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This study compared the surface detail reproduction and dimensional accuracy of stone models obtained from molds disinfected with 2% sodium hypochlorite, 2% chlorhexidine digluconate or 0.2% peracetic acid to models produced using molds which were not disinfected, with 3 alginate materials (Cavex ColorChange, Hydrogum 5 and Jeltrate Plus). The molds were prepared over matrix containing 20-, 50-, and 75-µm lines, performed under pressure with perforated metal tray. The molds were removed following gelation and either disinfected (using one of the solutions by spraying followed by storage in closed jars for 15 min) or not disinfected. The samples were divided into 12 groups (n=5). Molds were filled with dental gypsum Durone IV and 1 h after the start of the stone mixing the models were separated from the tray. Surface detail reproduction and dimensional accuracy were evaluated using optical microscopy on the 50-µm line with 25 mm in length, in accordance with the ISO 1563 standard. The dimensional accuracy results (%) were subjected to ANOVA. The 50 µm-line was completely reproduced by all alginate impression materials regardless of the disinfection procedure. There was no statistically significant difference in the mean values of dimensional accuracy in combinations between disinfectant procedure and alginate impression material (p=0.2130) or for independent factors. The disinfectant solutions and alginate materials used in this study are no factors of choice regarding the surface detail reproduction and dimensional accuracy of stone models.

Key Words: surface detail reproduction, dimensional accuracy, disinfectant solution, alginate.

## INTRODUCTION

Disinfection of tools and materials is an important step in dental procedures (1-3). In the absence of disinfection, treatment procedures can expose dentists, hygienists and laboratory workers to direct or cross-contamination (4,5). Impression materials are used in dentistry to make accurate casts of oral tissues. They must be capable of recording the anatomic topography of the desired area and remain dimensionally stable. During the impression procedure, the materials come into contact with fluids such as blood and saliva, which may contain pathogenic microorganisms. Infectious diseases such as herpes, hepatitis, tuberculosis or AIDS may be transmitted during this process (5,6).

Disinfectants must be effective as antimicrobial agents while not adversely affecting the dimensional accuracy or feature fidelity of the impression material and the resulting gypsum cast (7). The American Dental Association (ADA) recommends that alginate impressions be sprayed with an ADA-approved disinfectant and then sealed in a plastic bag for the recommended disinfection time (1,2). Spray disinfection of alginate impressions with 1% sodium hypochlorite (NaOCl) or 2% glutaraldehyde reportedly did not cause adverse dimensional changes or surface deterioration of stone models produced from the impressions (2,8). Moreover, the amount of water absorption and possible

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dimensional changes arising from the absorption varies with disinfectant concentration and type (8). Disinfection should be carried out with a product that requires the least amount of time for the disinfection process (9,10). Thus, other potential disinfectants to eliminate pathogens could be used, provided that they do not alter the properties of alginate materials.

Alginates are commonly used as a two-component system - powder and water. The powder contains sodium or potassium alginates (soluble alginates), diatomaceous earth acting as filler particles, calcium sulfate as reactor, a fluoride as accelerator and sodium phosphate as a retarder (11). The surface detail reproduction and dimensional accuracy properties are necessary for a true copy of the molded anatomical structures. Thus, those properties are being used to analyze this ability of the impression materials (7). A previous study reported that the dimensional change of alginate impressions in 100% relative humidity varied with the brand of impression material (8). However, molds are generally filled with plaster as quickly as possible, avoiding long exposure to air and the resulting syneresis and evaporation. If immediate casting is not possible, it is recommended that the mold be kept in a 100% relative humidity environment to preserve the water balance within the material. Many alginate manufacturers recommend that the models be cast within 12 h since increased dimensional change occurs after 12-24 h (12).

This study evaluated the surface detail reproduction and dimensional accuracy of stone models obtained from molds prepared using different alginate impression materials and disinfected using 2% NaOCl, 2% chlorhexidine digluconate (CHX) or 0.2% peracetic acid compared with stone models produced from molds that were not disinfected. The null hypotheses tested were that the surface detail reproduction and dimensional accuracy of stone models are not affected by the alginate impression material or the disinfectant solution.

## MATERIAL AND METHODS

The alginate impression materials Cavex ColorChange (Cavex Holland BV, Haarlem, The Netherlands), Hydrogum 5 (Zhermack, Badia Polesine, RO, Italy) and Jeltrate Plus (Dentsply Caulk, Milford, DE, USA) were used in this study.

The dimensional accuracy and surface detail reproduction were evaluated in accordance with the ISO 1563 standard (13). The molds were prepared over a matrix (38 mm outer diameter and 29.97 mm internal diameter) containing three parallel lines 20, 50, and 75 μm wide and 25 mm in length and spaced 2.5 mm apart. Two additional lines marked X and X′ were used to determine the dimensional accuracy and surface detail reproduction on the 50 μm line (Fig. 1).

Before performing the impression procedure, the matrix was ultrasonically cleaned and dried with compressed air. The alginate impression materials were prepared in accordance with the manufacturer's instructions. A perforated metal tray (31 mm internal diameter, 5 mm high) was placed on a glass plate and filled with the molding material. The tray was joined to the matrix and a pressure of 2 kgf was applied using a pneumatic press to simulate the impression process and allow for leakage of excess material (5).

The molds were removed 1 min after gelation (the gelation time was consistent with the minimum time recommended by the manufacturers) and disinfected using 2% NaOCl (Qboa; Indústria Anhembi S/A, Osasco, SP, Brazil), 2% CHX (Villevie clorhexidina; Dentalville do Brasil Ltda., Joinvile, SC, Brazil) or 0.2% peracetic acid (Peradesin; Ecoper Química LTDA, Mairiporã, SP, Brazil). Control samples were not disinfected. Disinfection consisted of spraying the samples with one of the solutions, covering with moist gauze, and sealing in closed jars at 100% relative humidity and 37 ºC for 15 min. The samples were divided into 12 groups (n=5) according to disinfectant procedure and

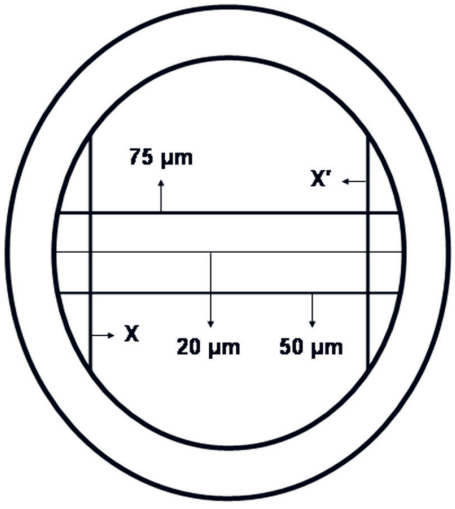


Figure 1. Schematic representation of apparatus (matrix) for measurement of surface detail reproduction and dimensional accuracy in accordance with ISO 1563.

alginate impression material: Group 1: No disinfectant (control group) + Jeltrate Plus; Group 2: No disinfectant (control group) + Cavex ColorChange; Group 3: No disinfectant (control group) + Hydrogum 5; Group 4: 2% NaOCl + Jeltrate Plus; Group 5: 2% NaOCl + Cavex ColorChange; Group 6: 2% NaOCl + Hydrogum 5; Group 7: 2% CHX + Jeltrate Plus; Group 8: 2% CHX + Cavex ColorChange; Group 9: 2% CHX + Hydrogum 5; Group 10: 0.2% Peracetic acid + Jeltrate Plus; Group 11: 0.2% Peracetic acid + Cavex ColorChange; and Group 12: 0.2% Peracetic acid + Hydrogum 5.

The disinfected and control molds were rinsed with 150 mL of distilled water, dried and filled with gypsum plaster (Durone IV; Dentsply Caulk) 15 min and immediately after impression, respectively. The stone models were separated from the tray containing the alginate 1 h after the start of the stone mixing.

Measurements of surface detail reproduction were performed using an optical microscope (SZM; Bel Engineering srl, MI, Italy). The stone models were examined under low-angle illumination at magnifications of ×4 to ×12 to determine whether the 50 μm-line was completely reproduced over the full 25 mm length between the intersecting reference lines (X and X′), in accordance with the ISO 1563 standard (13).

Dimensional accuracy measurements were performed on the stone models using an optical microscope (STM; Olympus Optical Co Ltd, Japan) with an accuracy of 0.0005 mm. The dimensional accuracy expressed as a percentage (L) was calculated in accordance with ISO 1563 (13) using the equation:

L= [(L2 – L1) / L1] x 100, in which L1 is the distance between the lines on the matrix and L2 is the distance between the lines on the stone models. The dimensional accuracy results were subjected to the Kolmogorov-Smirnov test for normality, and then to two-way ANOVA (material x disinfectant).

Table 1. Mean values of dimensional accuracy (%) for the different groups.

| Alginate impression material | No disinfectant (control) | 2% NaOCl | 2% CHX | 0.2% Peracetic acid |
|---|---|---|---|---|
| Jeltrate Plus | 100.01 (0.20) | 100.16 (0.07) | 100.29 (0.16) | 100.25 (0.20) |
| Cavex ColorChange | 100.09 (0.23) | 100.05 (0.22) | 100.17 (0.16) | 100.08 (0.12) |
| Hydrogum 5 | 100.20 (0.16) | 100.04 (0.08) | 100.06 (0.09) | 100.09 (0.23) |

NaOCl: sodium hypochlorite. CHX: chlorhexidine digluconate. Standard deviations are provided in parentheses.

## RESULTS

The surface detail reproduction of all alginate impression materials was completely reproduced on the 50 μm-line regardless of disinfection procedure (100% of the 5 samples of the 12 groups). There was no statistically significant difference in the mean values of dimensional accuracy in combinations among the disinfectant procedures and alginate impression materials (p=0.2130) or for independent factors (material and disinfectant) (Table 1).

## DISCUSSION

The decontamination of impression materials is essential for the control of cross-infection (7). The effect of alginate impression storage following spraying with disinfectant solution on the dimensional stability of the subsequent stone models has been previously investigated (8,14). The reports vary markedly in their choice of disinfectant concentration and procedure, making it difficult to assess the most appropriate method (7). The most frequently used disinfectants are glutaraldehyde, formaldehyde, alcohol, iodine solution, synthetic phenol, NaOCl and other chlorine-releasing solutions (5). However, few studies have assessed the interaction between the type of alginate impression material and disinfection with peracetic acid. In the present study, disinfection consisted of a 15-min treatment with 2% NaOCl, 2% CHX or 0.2% peracetic acid.

It is recommended that the impressions be stored in sealed bags following treatment with glutaraldehyde or NaOCl (1,15). Glutaraldehyde is considered a high-level disinfectant (16) that should eliminate some spores, the bacillus responsible for tuberculosis, vegetative bacteria, fungi, and viruses. However, the use of glutaraldehyde has been banned in some Brazilian states. Substances containing chlorine, such as 2% NaOCl, are considered intermediate-level disinfectants that have limited effect on bacterial spores and non-lipid containing viruses, but are effective against tuberculosis bacilli, vegetative bacteria, and most fungi.

CHX is a cationic bisbiguanide [1,6-di

(4-chlorophenyl-diguanido) hexane] agent with a broad antibacterial spectrum (Gram-negative and Gram-positive), and some virus and antifungal activities (10). It is also biocompatible with oral tissues (10) and has the ability to remain on a surface and be gradually released (10,17). Its excellent properties have motivated its increasing use in dentistry. Moreover, the antimicrobial may be contained in the power/liquid alginate materials (10). However, the response of microorganisms to the chemical agent depends, among others, on the type of microorganism. In a previous study, CHX showed no response on *Pseudomonas aeruginosa* (Gram negative bacillus), probably because this strain is resistant to CHX (10). Thus, CHX is also considered an intermediate-level disinfectant. Peracetic acid is a combination formed from the chemical reaction of acetic acid ($CH_3COOH$) with an aqueous solution of hydrogen peroxide ($H_2O_2$) or by the reaction of tetraacetylethylenediamine with alkaline hydrogen peroxide solution (18). In addition to being a high-level disinfectant, it is also biodegradable and nontoxic.

In the present study, the surface detail reproduction and dimensional accuracy (Table 1) of stone models were not affected by the choice of disinfectant solution or alginate impression material. In a previous study (19), the surface detail reproduction of stone models and dimensional change of 10 alginate products stored in 100 % relative humidity for 2 h were investigated. Amongst these products, some typical products were sprayed with disinfectant and sealed in storage bags for 2 h (19). It was found that storage for 2 h after spraying with either 1 % NaOCl or 2 % glutaraldehyde did not affect the dimensional change and deformation of stone models obtained from alginate impression, which was characterized by little contraction in 100% relative humidity (19). However, peracetic acid is a more powerful oxidant agent than chloride and chloride dioxide, causing the rupture of the cell membrane by means of protein denaturing (18,20). Due to its high level of disinfection, peracetic acid would appear to be the solution of choice. However, in a pilot study, solutions containing higher concentrations of peracetic acid caused bubbles in alginate molds.

The cast surfaces of impressions that were rinsed with water and stored in sealed plastic containers at 100% humidity were better than those that were poured immediately after rinsing (14,21). According to Tan et al. (14), this is due to a decrease in exudates from syneresis (which retard the setting of dental plaster and affect the cast surface) during storage. In the present study, the samples were stored for 15 min during disinfection and no deterioration in detail reproduction was observed.

The alginate impressions were covered with moist gauze during storage. The amount of water absorption varies with disinfectant concentration and type (8). This occurs because water is displaced in response to differences in osmotic pressure between the impression and the disinfectant solution, as well as the chemical action of the disinfectant on the impression (8,22). However, in the present study, stone models produced using Cavex ColorChange, Hydrogum 5 and Jeltrate Plus impressions exhibited no difference with respect to disinfectant solution. The disinfectant solution used by spraying showed no influence on surface detail reproduction or dimensional accuracy after storage. Results similar to those were found in other studies with other disinfectants probably with no immersion of alginate molds (7,19).

Acceptable methods of measuring the dimensional accuracy of casts include measuring calipers (7,22), micrometers (23), dial gauges (24), and measuring microscopes (25). The latter device was used in the present study due to its high accuracy (0.0005 mm). The largest dimensional deviation between the matrix and stone models was 0.29% (Jeltrate Plus with 2% CHX disinfection), which did not differ statistically from the other material/disinfection combinations. Alginate impression materials are typically recommended for prosthetics and orthodontic purposes where the level of accuracy is perceived as less critical (7). However, our results suggest that this impression material has sufficient dimensional stability for other uses as well.

Based on the obtained results, the null hypotheses were accepted, as there were no differences in [1] the surface detail reproduction or [2] dimensional accuracy of stone models produced using any of the alginate impression materials or disinfectant solutions. It may be concluded that there were no differences in surface detail reproduction or dimensional accuracy of stone models regardless of alginate impression material or disinfectant solution used in this study. The disinfectant solutions and alginate materials evaluated in the study are no factors of choice regarding surface detail reproduction and dimensional accuracy of stone models. The high-level disinfectant peracetic acid would be the material of choice for disinfection. Further studies are required to confirm its effectiveness in disinfection of alginate impression materials.

## RESUMO

Este estudo comparou a reprodução de detalhes da superfície e alteração dimensional de modelos de gesso obtidos a partir de moldes desinfetados com hipoclorito de sódio 2%, digluconato de clorexidina 2%, ou ácido peracético 0,2% a modelos confeccionados utilizando moldes que não foram desinfetados com três alginatos (Cavex ColorChange, Hydrogum 5, Jeltrate Plus). Os moldes foram preparados sobre matriz contendo linhas de 20, 50 e 75 µm realizado sob pressão com moldeira de metal perfurada. Os moldes foram removidos após a geleificação e desinfetados (utilizando uma das soluções por pulverização, armazenados em frascos fechados durante 15 min) ou não desinfetados. Assim, as amostras foram divididas em 12 grupos (n=5). Os moldes foram preenchidos com gesso dental Durone IV e uma hora após a manipulação do gesso os modelos foram separados da moldeira. A reprodução de detalhes da superfície e a precisão dimensional foram avaliadas usando microscopia óptica na linha 50 µm com 25 mm de comprimento, de acordo com a norma ISO 1563. Os resultados de precisão dimensional (%) foram submetidos à ANOVA. A linha de 50 µm foi completamente reproduzida por todos os alginatos, independentemente do processo de desinfecção. Não houve diferença estatisticamente significativa nos valores médios de precisão dimensional nas combinações entre procedimento de desinfecção e alginato (p=0,2130), ou para fatores independentes. Soluções desinfetantes e alginatos utilizados neste estudo não são fatores de escolha em relação à reprodução de detalhes da superfície e alteração dimensional de modelos de gesso.



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