British Journal of Medicine & Medical Research
17(9): 1-8, 2016, Article no.BJMMR.28035
ISSN: 2231-0614, NLM ID: 101570965

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Influence of the Disinfection Technique in Detail Reproduction and Dimensional Change of Plaster Casts Obtained from Different Alginate Impression Material Molds

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Authors' contributions

This work was carried out in collaboration between all authors. Author RDG designed the study, wrote the protocol, wrote the first draft of the manuscript and managed the literature searches. Author SBB performed the statistical analysis. Authors SBB, RVC, EHAGS, MBL, AGJ, SKM and MACS helped to draft the manuscript. Authors SBB, RVC, EHAGS, MBL, AGJ, SKM and MACS contributed to analyzing, reviewing and editing the data. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJMMR/2016/28035
Editor(s):
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(2) Matheus Guilherme Lucas, Paulo State University (UNESP), Brazil.
(3) Anonymous, Alexandria University, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/16114

Original Research Article

Received 30th June 2016
Accepted 4th September 2016
Published 9th September 2016

ABSTRACT

The aim was to evaluate the detail reproduction and dimensional change of alginates after using different disinfection techniques. The molds of three alginate (Jeltrate Plus, Hydrogum 5 and Cavex ColorChange) were prepared at the top surface of the matrix where there was three parallel lines 20, 50, and 75 µm wide and 25 mm length between two vertical lines marked X and X′ with

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perforated metal tray. The molds were disinfected using a 0.2% peracetic acid solution by spraying or immersion or not disinfected. The alginate impressions were poured with dental stone obtaining plaster casts. The detail reproduction and dimensional change of plaster casts were measured on the 50 µm wide and 25 mm length line with an optical microscopy and compared with the matrix. The dimensional change date (%) was analyzed with two way ANOVA (factors, disinfection technique and material) and post-hoc comparison was conducted with Tukey's test. The three alginates showed complete detail reproduction in the line of 50 µm. For the disinfection technique factor, models obtained from molds disinfected by the immersion technique differed significantly from models obtained from molds that were not disinfected. There is no difference in detail reproduction in plaster casts made from alginate molds, regardless of differences in disinfection technique or alginate used. There is a difference in dimensional accuracy in plaster casts made from alginate molds between molds disinfected by immersion and not disinfected; however, the difference found is not of clinical relevance.

Keywords: Detail reproduction; dimensional change; disinfectant solution; alginate.

1. INTRODUCTION

Diagnostic and working casts are commonly obtained from alginate molds because of the ease of use, low cost [1], and good patient acceptance [2]. The prostheses success can be influenced by several factors such as gelation characteristics [2,3], the rheological properties after gelation [4], and compatibility with dental gypsum plaster [1,5]. Alginate molding system consists of a powder containing sodium or potassium alginate (soluble alginate), calcium sulfate as a reactant, a diatomaceous earth filler, sodium phosphate as a retarder, and fluoride as an accelerator, and it is mixed with water [6,7]. After gelation reaction, in the alginate structure, gel fibrils are held together by primary bonds occurring due to the substitution of sodium ions by calcium ions on two neighboring molecules [8]. The gel forms as a complex, entangled structure that traps sodium alginate that has not reacted with the calcium salt, excess water, charged particles, and reaction byproducts [8]. Under these conditions, the final alginate structure is very sensitive to conditions that can change the amount of water trapped in the fibrillar assembly [8]. Consequently, the dimensional stability of an alginate mold is highly vulnerable to weather and moisture conditions during the storage period for disinfection before it is used to make the plaster model [8]. In this study were used Jeltrate Plus (Dentsply Caulk, Milford, DE, USA), Hydrogum 5 (Zhermack, Badia Polesine, RO, Italy), and Cavex ColorChange (Cavex Holland BV, Haartem, The Netherlands). Manufacturers of the last two reports that may remain stable for 5 days without changing their properties. The main component of these three alginates is silicon, however, with different percentages [6].

Alginates must be capable of recording the anatomic topography of the desired area and remain dimensionally stable [9] even after disinfection. To obtain an accurate reproduction of anatomical structures to be molded are essential properties of detail reproduction and dimensional change [9], thus they measure the effectiveness of the impression materials [10]. Disinfection of dental impression materials is an important step in dental procedures [1-3] and necessary to avoid cross contamination consequent on the presence of micro-organisms embedded on/in the impression materials from blood and saliva [11]. When the disinfection is not carried out, direct or cross contamination may occur between patients with laboratory workers, hygienists or dentists [4,5]. The actual microorganisms found have been reported, for example, by Jennings and Samaranayake (*Pseudomonas aeruginosa* and *Candida albicans*) [12], and Look et al. (*Herpes viruses*) [13], which recommend disinfection with periods greater than 10 minutes. Thus, considering the cross-contamination between the dental operatory and dental laboratory, dental prostheses must be disinfected before being sent to the laboratory and before being delivered to the patient [14,15].

Disinfection carried out by spraying with solutions (1% sodium hypochlorite or 2% glutaraldehyde solutions) caused no change in the molds or plaster gypsum models. [16,17]. Besides that, dimensional changes depend on the disinfectant and concentration that was used and amount of absorption of impression materials [16]. Alginate impression materials have been immersed in sodium hypochlorite, 2% gluteraldehyde, 2–4% propanolol, 0.5% chlorhexidine, 5.0% sodium salt of sulfanochloramide, 1.0% benzalkonium

chloride, a mixture of phenyl phenol and 0.5% chlorcresoliodophor, phenol gluteraldehyde, and glyoxal gluteraldehyde [18-20], and the effects on surface detail reproduction and dimensional accuracy were examined. Peracetic acid-based solutions have been used as chemical disinfection in the medical [21] and dental professions [22]. Peracetic acid is considered a feasible alternative because it is composed of acetic acid and hydrogen peroxide and its byproducts are biocompatible substances [23]. It is also considered as a bactericidal, virucidal, sporicidal, and fungicidal agent [24]. It has the advantage of remaining active even in the presence of organic matter, particularly blood, body fluids and fats [24]. However, studies were not found that examined immersion of alginate impression materials in peracetic acid; there was only a study that evaluated by spraying [9]. Guiraldo et al. [9] revealed differences in the surface detail reproduction in molds disinfected using concentrations greater than 0.2% peracetic acid. Thus, this study compared the detail reproduction and dimensional change of plaster casts obtained from molds prepared using Jeltrate Plus, Hydrogum 5, or Cavex ColorChange alginate materials and disinfection (spraying or immersion) with 0.2% peracetic acid to the models produced using molds that had not been disinfected. The null hypotheses tested were that the alginate impression material (1) or the disinfection technique (2) do not influence the properties of the detail reproduction and dimensional change.

2. MATERIALS AND METHODS

The matrix (where there was three parallel lines 20, 50, and 75 µm wide with 2.5 mm distance between them and 25 mm length between two vertical lines marked X and X′, Fig. 1) was cleansed in an ultrasound device and dried with compressed air. The molds of three alginates (Jeltrate Plus, Hydrogum 5 and Cavex ColorChange) were prepared at the top surface of the matrix with outer diameter of 38 mm and 29.97 mm internal diameter in accordance with the manufacturer's instructions. The essay of detail reproduction and dimensional change were verified on the 50 µm line according to the standards of ISO 1563 [25].

A perforated metal tray with 5 mm high and 31 mm internal diameter was put on a glass plate and occupied with alginate impression material. The tray was coupled to the matrix and a pressure of 2 kgf was performed with a pneumatic press to simulate the molding procedure and to allow leakage of excess material [26].

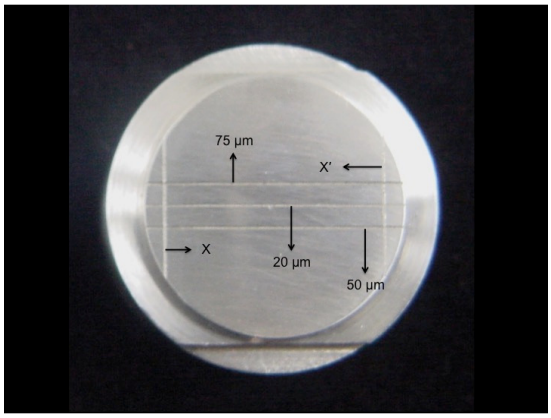

Fig. 1. Matrix with three parallel lines 20, 50, and 75 µm wide with 2.5 mm distance between them and 25 mm length between two vertical lines marked X and X′

One minute after the alginate setting, the tray with the mold was separated from the matrix and disinfected using a 0.2% peracetic acid solution (Peradesin; Ecoper química LTDA, Mairiporã, SP, Brazil) by spraying or immersion or not disinfected. The specimens disinfected by spraying technique were covered with moist gauze, sealed in closed jars at 100% relative humidity at 37°C and stored for 15 minutes; and the specimens disinfected by immersion technique were immersed in closed jars with the solution at 37°C for 15 minutes. Thus, nine groups (n=5) according to disinfection technique and alginate impression material were separated (Table 1): Group 1– immediately without disinfectant, Jeltrate Plus; Group 2– immediately without disinfectant, Hydrogum 5; Group 3– immediately without disinfectant, Cavex ColorChange; Group 4– spraying, Jeltrate Plus; Group 5– spraying, Hydrogum 5; Group 6– spraying, Cavex ColorChange; Group 7– immersion, Jeltrate Plus; Group 8– immersion, Hydrogum 5; Group 9– immersion, Cavex ColorChange.

The specimens disinfected by spraying or immersion (after 15 minutes) and immediately without disinfectant (control) were washed with 150 mL of distilled water, dried, and poured with dental stone (Durone IV; Dentsply Caulk, Milford, DE, USA). The plaster casts were separated from the tray containing the alginate impression after the gypsum final setting.

Table 1. Experimental groups

Disinfection technique	Alginate impression material		
	Jeltrate plus	Hydrogum	Cavex color change
Immediately without disinfectant	Group 1	Group 2	Group 3
Spraying	Group 4	Group 5	Group 6
Immersion	Group 7	Group 8	Group 9

For detail reproduction measurements, the plaster casts were evaluated using an optical microscope (SZM, Bel Engineering srl, MI, Italy) under low-angle illumination at a magnification of 4x to 12x to establish whether the 50-µm line was copied along its entire length (25 mm) [25].

For dimensional change measurements, the plaster casts and matrix were evaluated an optical microscope (STM, Olympus Optical Co Ltd., Japan) with an accuracy of 0.5 µm. The calculation in percentage (L) was:

$$L = [(L2 - L1)/L1] \times 100 \text{ [25]}$$

Where L2 is the distance between the lines on the plaster casts and L1 is the distance between the lines on the matrix.

Then, 100% was added to the results of the equation, and the dimensional change date [8] was subjected to the Kolmogorov-Smirnov test for normality. Then, data were than analyzed with two way ANOVA (factors, disinfection technique and material). The post-hoc comparison was conducted with Tukey's test. A standard level of significance of 5% was adopted (α=5).

3. RESULTS

Cavex ColorChange, Jeltrate Plus and Hydrogum 5 showed complete detail reproduction in the line of 50 µm (Fig. 2) regardless of disinfection technique or material (100% of the five samples of the groups: group 1– immediately without disinfectant, Jeltrate Plus; group 2– immediately without disinfectant, Hydrogum 5; group 3– immediately without disinfectant, Cavex ColorChange; group 4– spraying, Jeltrate Plus; group 5– spraying, Hydrogum 5; group 6– spraying, Cavex ColorChange; group 7– immersion, Jeltrate Plus; group 8– immersion, Hydrogum 5; group 9– immersion, Cavex ColorChange).

There was no statistically significant difference in the mean values of dimensional stability in combinations between disinfection technique and material (p=0.951) or the material factor (p=0.549, Table 2).

For the disinfection technique factor, models obtained from molds disinfected by immersion technique differed significantly from models obtained from molds that were not disinfected (p=0.033, Table 3).

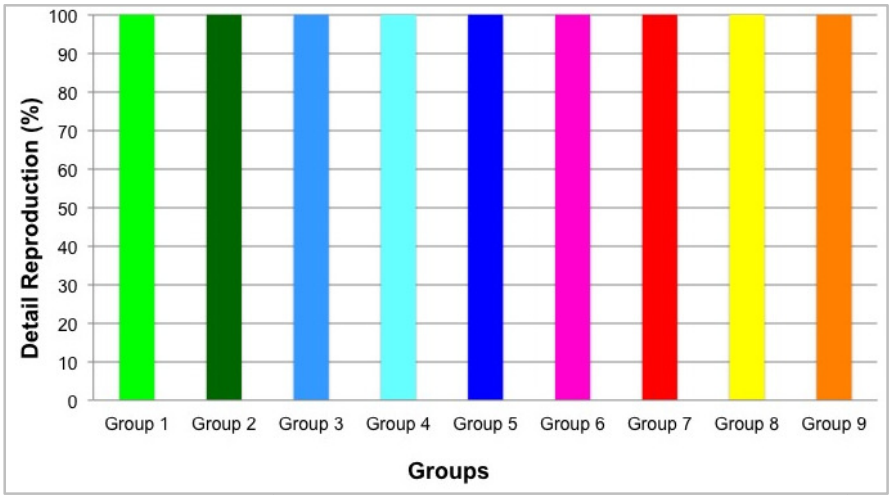

Fig. 2. Detail reproduction (%) according to different groups.

Table 2. Mean values of dimensional change (%) for different alginate impression materials (material factor)

Alginate impression material	Dimensional change (%)
Cavex color change	100.09 (0.16) A
Jeltrate plus	100.05 (0.13) A
Hydrogum 5	100.04 (0.09) A

Different capital letters differ by Tukey's test with 5% significance. Standard deviations are provided in parentheses

Table 3. Mean values of dimensional change (%) for different disinfection techniques (disinfection technique factor)

Disinfection technique	Dimensional change (%)
Immersion	100.12 (0.20) A
Spraying	100.09 (0.11) AB
Not disinfected	99.98 (0.11) B

Different capital letters differ by Tukey's test with 5% significance. Standard deviations are provided in parentheses

4. DISCUSSION

In dental practice, many infectious diseases, bacterial or viral origin, may be transmitted from the oral cavity of the patient and for the professional environment, initiating cross-infection. Similarly, professionals of health may constitute a true vehicle of propagation, since not all patients with infectious diseases can be identified by medical history, physical examination or laboratory tests. Thus, the disinfection of instruments and materials is an important step in dental procedures [17]. For cross infection control is indispensable the decontamination of molding materials [10]. Previous studies [16,27,28] have investigated the effect of immersion and spraying of disinfectants solutions on dimensional change of alginate. The choice and concentration of disinfectant and method used for this purpose varies greatly according to the literature [10]. Glutaraldehyde, synthetic phenol, alcohol, formaldehyde, iodine solution, sodium hypochlorite and other chlorine releasing solutions are the disinfectants most commonly employed in Dentistry [26]. Nevertheless, there has been little examination of the alginate molds disinfected with peracetic acid. The chemical reaction of an aqueous solution of hydrogen peroxide (H_2O_2) with acetic acid (CH_3COOH) and the reaction of alkaline hydrogen peroxide solution with tetraacetylethylenediamine form the peracetic acid (high-level disinfectant, biodegradable and nontoxic) [9,29]. Thus, in the present study, disinfection consisted of a 15-minute treatment with 0.2% peracetic acid by different techniques (immersion or spraying).

The disinfectant solution or alginate is not selection factor for property detail reproduction when using the technique by spraying [9]. The detail reproduction of alginate molds stockpiled for 2 hours after spraying with 1% sodium hypochlorite or 2% glutaraldehyde solutions was not changed in ten trademarks [30]. Immersion of alginate impressions in glutaraldehyde solution has been shown to degrade the surface of the resulting stone casts [28]. The effects of immersion in sodium hypochlorite solution on the surfaces of stone casts obtained from alginate impressions appear to vary among the brands of impression materials [28]. Nevertheless, peracetic acid promotes the rupture of the cell membrane by means of protein denaturation and it is a better oxidant agent compared to chloride and chloride dioxide [29,31]. In this study, the detail reproduction of plaster casts was not affected when the alginate molds were immersed in 0.2% peracetic acid, in accordance with a previous study that used the spraying technique [9]. Peracetic acid with a concentration of 0.2% (bubbles were found with higher concentrations) is the choice for disinfecting alginate molds due to the high level disinfection promoted by this solution [9].

Guiraldo et al. [6] revealed differences in the inorganic composition, analysis of morphology/size of the filler particles and volumetric filler fraction of alginates used in the current study, hypothesizing that these differences could lead to different results when the mechanical properties were tested. However, in this study, differences were not found among alginates when dimensional change property was evaluated (Table 2). Thus, other properties could be affected. The immersion of alginate impressions in 1% and 0.5% sodium hypochlorite solutions for 15 minutes has been reported to slightly affect the dimensional change of stone casts. There are generally two disinfecting methods available, namely the use of aerosols or immersion in disinfecting solutions [32]. Clearly, either method should not compromise the dimensional stability of the impression material. With alginate impression materials, dimensional changes are known to occur in immersion in water and artificial saliva [33]. Often, the alginate

initially swells but then shrinks until ultimately the process equilibrates with a net shrinkage. Other sources suggest that alginates swell continuously with time upon immersion in water [11]. In this study, there was a difference between the plaster casts arising from molds disinfected by immersion and the molds that were not disinfected. However, the difference found was not of clinical relevance because the alginate impression is used in dental practice that is typically recommended for prosthetics and orthodontic purposes and for which the level of change is perceived as less critical [10]. Future studies are needed to confirm the greater effectiveness of the disinfectant peracetic acid by the immersion disinfection technique when compared to the spraying technique. Thus, based on the results of this study, the first null hypothesis was accepted, as the alginate impression material did not influence the property of the detail reproduction, and the second null hypothesis was not accepted, as the disinfection technique influenced the property of the dimensional change.

5. CONCLUSION

Based on the results that have been analyzed and discussed, the following conclusions can be observed:

The results led to similar values of the detail reproduction in plaster casts made from alginate molds, regardless of differences in the disinfection technique or alginate used.

The results led to no similar values of the dimensional change in plaster casts made from alginate molds between molds disinfected by immersing and those that were not disinfected; however, the difference found is not of clinical relevance.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

ACKNOWLEDGEMENTS

The authors wish to thank engineer Marcos Blanco Cangiani (Piracicaba Dental School, State University of Campinas) for assistance with the making of the matrix.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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