Dimensional Stability of Alginate Impression Materials in the use of Electrolyzed Oxidizing Water as an Environmentally Friendly Disinfectant

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Abstract

There has yet to be any recent data on the effect of more environmentally friendly disinfectant Electrolyzed Oxidizing Water (EOW) on the dimensional stability of alginate material.

In this experimental laboratory study, 126 specimens of alginate material were divided into three groups and disinfected by spraying with EOW, Glutaraldehyde 2%, and NaOCl 1% solution. Dimensional stabilities were observed at 1 minute and 10 minutes after the disinfection procedure.

There was no statistically significant difference in alginate dimension stability in all treatment groups. The smallest dimensional changes were found in the EOW groups, with a delta average ($\bar{X}\Delta$) of 0.07mm in the 1-minute procedure and 0.32mm in the 10-minutes procedure.

EOW as disinfectant material has the smallest alginate dimensional stability change compared to Glutaraldehyde 2% and NaOCl 1% in both 1-minute and 10-minutes disinfection procedures.

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Introduction

Dentists are prone to infection sources.[1] There are bacteria, fungi, and pathogen microorganisms that can potentially become a source of infection.[2] The treatment carried out by the dentist will also produce aerosols, causing an opportunity for cross-infection between health workers and patients.[3] In dentistry, one treatment procedure that is susceptible to the risk of cross-contamination is the impression procedure.[4,5] After producing a cast from the impression, the model casts will then be sent to the dental laboratory to manufacture dentures. A study conducted by Powell et al. found that as much as 67% of the impression results sent to the dental laboratory were contaminated with various types of microbes. Therefore it is necessary for dentists to disinfect the impression result to reduce the risk of cross-contamination.[6,7]

The disinfection process kills vegetative forms of the most harmful and pathogenic organisms.[8] There are various kinds of disinfectants which are divided into three levels based on their effectiveness against vegetative bacteria, tubercle bacilli, fungal spores, viruses, and bacterial endospores: high level (Glutaraldehyde 2%), medium level (sodium hypochlorite 0.5%, iodoform 1-2%, fenol 1-3%, chlorhexidine 2-4%, and alcohol 70%), and low level (quaternary ammonium).

Alginate is the most often impression material used in dentistry to obtain a negative form of the teeth and soft tissues of the oral cavity. Alginate material, equipped with good wetting properties, has a simple manipulation technique and a relatively short working procedure. On the other hand, alginate has hydrophilic properties, which makes this ingredient easily distorted.[9] Recommended disinfectant ingredients for alginate impression material is NaOCare1% and Glutaraldehyde 2%; however, previous study found that the use of Glutaraldehyde 2% and NaOCl 1% may cause a change in dimension stability in the alginate impression material.[10–12] The dimensional stability of impression material is an important thing to note because dimensional changes can have a major effect on the dentures produced based on casts made by these impression materials leading up to the success of the

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prosthesis to be used by the patient. Alginate impression material has syneresis and imbibition potentials which need to be considered when choosing disinfection procedures. The golden standard for disinfection impression material is an immersion method, but in 1996 America Dental Association (ADA) recommended a spraying method for alginate impression material using chemical disinfectants such as Glutaraldehyde or NaOCl and leaving it standing for 10 minutes.[10,12] A previous study by Rueggeberg et al. explained that either spraying or immersion disinfection methods have equal bactericidal effectiveness; the spraying method is preferred for the alginate impression material to avoid distortion like syneresis or imbibition.[7]

Chemical disinfectants are potentially containing chlorine that may have a negative impact on the environment. Chlorine is a potent oxidizing agent which can react with organic compounds in water to form organochlorine compounds and cause environmental pollution and global warming.[13] Machiko et al. stated that water pollution is caused by an inadequate waste disposal system.[14] To minimize negative environmental impacts, more environmentally friendly disinfectant chemicals shall be required.

There have been emerging studies concerning disinfectant material originating from Hypochlorous Acid Electrolyzed Water as an alternative disinfectant.[15] Hypochlorous Acid Electrolyzed Water, commonly called Electrolyzed Oxidizing Water (EOW), is the result of the electrolysis of 0.05% – 2% sodium chloride (common salt). EOW is easy to produce and, in Japan, has been certified for use as a medical product and safe disinfectant agent as it will revert back into NaCl (salt) and water; thus it is considered environmentally friendly.[16,17] To produce EOW, a specific electrolysis device is needed. Home Guard is an electrolysis device for producing disinfectant liquids registered with the FDA. The device has four layers electrode (TLE), which produces hypochlorous acid with an ion concentration of 1 – 200 ppm and an alkaline pH value with a range of 7,2 – 8.80. KR BIOTECH activity test has proven that the disinfectant solution produced from the device is able to reduce 99,9% of the SARS-CoV-2 virus, bacteria (E.coli, Enterococcus, Pseudomonas aeruginosa, Staphylococcus aureus, and fungi candida Albicans).[18,19]Previous study conducted by Jeyapalan et al. has shown that the effectiveness of reducing microbes in EOW is better than 1% sodium hypochlorite and Glutaraldehyde 2,4%.[11] In addition, a study by Nagamatsu et al. has shown that EOW is proven to have good bactericidal effectiveness on alginate impression material after being immersed for 1 minute.[15]

Mahalakshmi et al. compared the effects of EOW, 2% Glutaraldehyde, and 1% NaOCl on changes in dimensional stability in polyvinyl siloxane (PVS) impression material.[17] No studies have analyzed the effects of changes in the dimensional stability of EOW on alginate impression material. This study was performed to determine the effect of EOW on the dimensional stability of alginate impression material, compared to other more known disinfectant materials (2% Glutaraldehyde; and 1% NaOCl) by spraying method and allowing it to stand for 1 minute and 10 minutes.[17,20]

Materials and methods

This study is an experimental laboratory study. The EOW was made according to previous research with the main ingredient of table salt dissolved in tap water continued with electrolyzed by the electrolysis device (Home Guard device), while Glutaraldehyde 2% and NaOCl 1 % were prepared and made fresh for the experiment. [17]

In this study, there were six treatment groups, alginate impression material disinfected with 1-minute and 10-minute disinfectant EOW, 1-minute and 10-minute Glutaraldehyde 2%, and 1-minute and 10-minute 1% NaOCl. The number of samples selected for each group is 19 samples. To anticipate drop-outs, the number of samples for each group was increased by 10%, so the number of samples needed for each group was 21, consisting of 20 samples for the disinfection group and one sample as a control for each group. The total number of samples necessary for these six groups was 126 samples. Samples were made using alginate impression material processed according to specification for Dentistry - Hydrocolloid Impression Materials (ISO 21563: 2013)[21] then poured onto the metal mold ring and the concomitant cylinder ruler block until it hardened within 3 minutes. The resulting alginate discs had three parallel lines that duplicated three engraved lines A, B, and C from the metal mold for measurement points

(Figure 1A).[21,22] Measurements then were taken by a single operator using a digital caliper at the time before disinfection (P), and after the disinfection process within 1 minute (P1) and 10 minutes (P2).[11,18,23] Diagram of the metal ring showing line B measurement between point Y and Y1 (Figure 1B).[22] The measurement results were recorded before the disinfection procedure, then sprayed with disinfection chemicals and let stand for 1-minute, after which three more measurements were taken consecutively, and the average of these measurements was to be recorded as a measurement after disinfection. The same procedure of measurement was performed in the 10-minutes disinfection group.

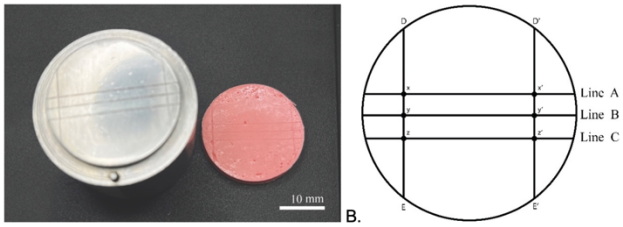

Figure 1. A. Representative image sample was made by pouring alginate impression material onto the metal mold ring and then topping with the cylinder marked by three lines block until it hardened**. B.** Measurement scheme of dimensional stability change in the sample of alginate impression material, area measurement at line B was made from the point Y to Y'.

Results

In this study, the dimensional stability of the alginate impression material is evaluated to see the effect of the disinfection procedure by spraying, compared to the three different types of disinfectants (EOW, Glutaraldehyde, NaOCl). Bivariate analysis was carried out to compare changes in the dimensional stability of alginate that occurred between groups of disinfectants at each measurement time (1 minute and 10 minutes).

The analysis results showed that the average change in alginate dimensions of 20 samples disinfected with EOW for 1 minute was 0,07mm with a standard deviation of 0,27mm. In samples disinfected with disinfectant EOW for 10 minutes, there was a change of 0,32mm with a standard deviation of 0,27mm. The mean change in alginate dimensions of 20 samples disinfected with Glutaraldehyd for 1 minute was 0,15mm with a standard deviation of 0,15 mm. In samples disinfected with Glutaraldehyd for 10 minutes, there was a change of 0,33 mm with a standard deviation of 0,22 mm. The average alginate dimensional change of 20 samples disinfected with NaOCl for 1 minute was 0,09 mm with a standard deviation of 0,11 mm. In samples disinfected with NaOCl for 10 minutes, there was a change of 0,33 mm with a standard deviation of 0,15 mm (table 1). It can be concluded that the longer the disinfection time, the greater the imbibition will have occurred; and a small standard deviation value; showed better measurement accuracy. The normality test was then used to determine the type of hypothesis testing analysis; it was found that the data was normally distributed with a significance level >0.05 (table 2).

Type	Time (minutes)	Delta mean ± SD	N
EOW	1	0,07 ± 0,27	20
	10	0,32 ± 0,27	20
Glutaraldehyde	1	0,15 ± 0,15	20
	10	0,33 ± 0,22	20
NaOCl	1	0,09 ± 0,11	20
	10	0,33 ± 0,15	20

Table 1. The Alginate Dimensional Stability Changes At 1- Minute And 10-Minutes. Disinfection Procedures in the Three Different Types of Disinfectants.

Type of disinfectant	Time	Kolmogorov - Smirnov Sig.
EOW	1 minute	0,16*
	10 minutes	0,20*
Glutaraldehyde	1 minute	0,01
	10 minutes	0,01
NaOCL	1 minute	0,11*
	10 minutes	0,08*

*p > 0,05 means the data is normally distributed

Table 2. The Normality Test for The Alginate Dimensional Stability Changes At 1- Minute And 10-Minute Disinfection Procedures in the Three Different Types of Disinfectants.

Type of disinfectant	Delta Average ($\bar{X}\Delta$)	Median (min—max)	P value
EOW	0,07	0,07 (-0,44 – 0,87)	
Glutaraldehyde	0,15	0,11 (-0,02 – 0,68)	0,31
NaOCl	0,09	0,10 (-0,20 – 0,24)	

Note: * p <0,05
** Analysis using the Kruskal-Wallis test

Table 3. The comparison of The Alginate Dimensional Stability Changes At 1- Minute. Disinfection Procedures in the Three Different Types of Disinfectants.

Type of disinfectant	Delta Average ($\bar{X}\Delta$)	Median (min—max)	P value
EOW	0,32	0,32 (-0,28 – 0,97)	
Glutaraldehyde	0,33	0,23 (0,09 – 0,72)	0,801
NaOCl	0,33	0,28 (0,16 – 0,57)	

Note: * p <0,05
** Analysis using the Kruskal-Wallis test

Table 4. The comparison of The Alginate Dimensional Stability Changes At 10 – Minute. Disinfection Procedures in the Three Different Types of Disinfectants.

Data of delta dimension changes of alginate

using Glutaraldehyde disinfection procedures was abnormal in 1-minute and 10-minutes; (P value <0.05), this led to non-parametric analysis using the Kruskal-Wallis. From the result of the Kruskal-Wallis test at 1-minute procedure (table 3), it can be concluded that the average results of the changes in dimensional stability of alginate disinfected with EOW have the smallest value compared to Glutaraldehyde 2% and 1% NaOCl. Furthermore, in the 10 minutes group, EOW showed the smallest value of changes in dimensional stability (table 4). This study showed there is no statistically significant difference in the dimensional stability changes of alginate impression materials disinfected using three types of disinfectant materials either at 1 minute or 10 minutes, and that EOW offered the smallest dimensional changes compared to 2% Glutaraldehyde and 1% NaOCl.

Discussion

Two disinfection techniques can be used to prevent cross-contamination in alginate impression material, namely by immersion or spraying. However, there is a potential problem after the disinfection procedure, which is a change in the dimensional stability of the impression material. Alginate impression materials have syneresis and imbibition properties because this material is in the form of a gel. These will result in a change in size so that the impression material tends to expand and produces an inaccurate impression. Factors to be considered when carrying out the disinfection procedure are the method, the type of disinfectant, the effectiveness and stability of the chemicals contained, and the length of time for disinfection. These factors potentially affect changes in dimensional stability and have a lethal effect on bacteria.[24,25] The immersion method is not recommended for alginate materials because of the nature of the alginate material, which is very hydrophilic, so it is more advisable to use the spray method. The immersion or spraying methods in the disinfection procedure do not affect the ability to kill bacteria. Still, in the spraying method, it is necessary to pay more attention to all parts of the surface exposed to disinfectants. Furthermore, based on the results from a previous study by Hamedi et al. examined the dimensional stability in alginate impression materials after disinfection by spraying and immersion with 5% sodium hypochlorite and 2% glutaraldehyde; the immersion method was not recommended.[26]

The American Dental Association (ADA) recommends a 10-minute disinfection procedure for NaOCl, and the Japan Prosthodontic society recommends a 30 minutes disinfection procedure for 1% NaOCl and 2% Glutaraldehyde.[23] In our study, we also use a 1-minute disinfection procedure based on a study conducted by Nagamatsu et al. EOW effectively kills bacteria within 1 minute, no matter the concentrations of pH used.[15] Nevertheless, neutral pH showed a larger effect of decreasing the bacteria on the impression than strong acid pH; in addition, the largest disadvantages of strong acid water are the severe corrosiveness to metal tray used for alginate impression and erosiveness due to its low pH value.[15] Previous studies stated that EOW has fast and strong bactericidal activity, is the least harmful to biological tissues, and that complete disinfection of alginate impression materials can be achieved in just 1 minute.[15,27]

In this study, the EOW used had an alkaline pH of 8.3 which was a universal setting from the electrolysis device. It has been proven that the bactericidal effectiveness of EOW with a pH concentration produced by the Home Guard machine can kill bacteria and viruses by 99.9%.[19,28]

From the results of statistical tests carried out with Kruskal-Wallis, the dimensional changes that occurred in the EOW disinfection procedure proved to be the smallest among the three disinfectants, with an average delta of 0.07mm at 1 minute and 0.32mm at 10 minutes. The 10 minutes group results of this study are in line with Santoso et al., who examined the dimensional stability of alginate impression materials in different time lengths of disinfection procedures and found that the effect of 10 minutes of disinfection procedure towards dimensional stability can still be tolerated.[29] These results are also in line with previous research by Sari et al. (2013), along with research results of Amelia et al. (2017), proofing that 10 minutes disinfection procedure resulted in dimensional alginate changes that are still within tolerance limits.[20,26]

The result of this study has a high potential application in clinical practice; EOW as a disinfectant material results in minimal changes in dimensional stability in alginate impression material and effectively kills bacteria in a very short time will help to speed up the treatment in dental offices. One of the advantages of EOW is its easiness in producing an environmentally friendly disinfectant using raw materials that are relatively easy to obtain. However, the weakness of this EOW material is that when stored in an open container or exposed to direct sunlight, it will cause a decrease in the Hypoclorus Acid content that acts as a bactericidal active substance in EOW.[11] Storage of the EOW solution should be in a closed container and put in a nondirect sunlight shady place; that way, it will have a longer shelf life, which is around one week. Furthermore, storage of EOW at 4°C will result in a more stable solution than storage at room temperature; either way, EOW is highly recommended to be used as soon as possible upon making.[11] From the results of this study, it can be stated that the use of EOW as a more environmentally friendly disinfectant material has the

slightest change in dimensional stability in alginate impressions due to its presumed effectiveness in the short exposure time. The limitation of this study is that we did not confirm the bactericidal effect prior to the measurement of dimensional stability. Since this study is an in vitro study, further study is needed in clinical settings to ensure the the effectiveness of EOW as a disinfection material with the slightes dimensional stability changes.

Conclusions

EOW has the slightest change in alginate dimensional stability compared to 2% Glutaraldehyde and 1% NaOCl in either 1-minute or 10-minute spraying disinfection procedures. Three types of disinfectant materials (EOW, Glutaraldehyde 2%, and NaOCl 1%) offer changes in dimensional stability that are still clinically acceptable. EOW can be used as an alternative disinfectant material for clinical applications.

Declaration of Interest

The authors report no conflict of interest.

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