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Setting Time of Alginate in Disinfectant Solutions: An In Vitro Study

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Abstract

Background: While making an impression, oral fluids like saliva, blood, and other exudates that may contain pathogenic micro-organisms come in contact with impression materials and increase the risk of infection to dental practitioners, patients, and laboratory personnel. To prevent cross-infection, all impressions should be thoroughly disinfected. The objective of this study was to investigate and compare the time taken by alginate to set when mixed with 1% povidone iodine and 0.1% chlorhexidine.

Methods: In this in vitro experimental study, a total of 69 samples were divided into three groups of 23 each based on the liquid used for mixing alginate. The liquids used were water, 1% povidone iodine, and 0.1% chlorhexidine. The setting time was calculated following ADA specification no 18. Collected data were entered in Microsoft Excel 2016 and converted into Statistical Package for Social Science (SPSS) version 20.0 for statistical analysis. The data were analyzed using one-way ANOVA and a post hoc test.

Results: The setting time of alginate was prolonged when 0.1% chlorhexidine and 1% povidone iodine were used as mixing liquids as compared to water. One-way ANOVA and post-hoc Tukey test revealed statistically significant differences in setting time between all three groups ($p<0.001$).

Conclusion: The setting time was prolonged when 1% povidone iodine and 0.1% chlorhexidine were used to mix the alginate powder. However, it may be clinically acceptable according to the established standards of ADA specification no 18, which allows a time up to 4.5 minutes for regular set impression materials.

Keywords: Alginate impressions; Disinfection; Setting time

Declarations

Ethics approval and consent to participate: This study was conducted with prior ethical approval from the Institutional Review Committee of BPKIHS (IRC/2230/022). This study is an in vitro experimental study.

Consent for publication: Not applicable.

Availability of data and materials: Available upon request to the corresponding author.

Competing interest: None.

Funding: None.

Authors' contributions: PKP: Concept, design of study, manuscript review, final approval

BP: Literature search, data acquisition, data analysis, statistical analysis, manuscript preparation

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BACKGROUND

Most prosthodontic treatments start with a routine impression-making procedure [1]. Among various impression materials, alginate is still the most commonly used [2, 3]. While making an impression, oral fluids like saliva, blood, and other exudates that may contain pathogenic microorganisms come in contact with impression materials [4]. With the possibility of cross-infection, each patient should be considered potentially infected, and so all impressions should be thoroughly disinfected [5]. Based on guidelines established by the American Dental Association and Centre for Disease Control spray and immersion are the most widely used disinfection technique for alginate [6 - 8].Although disinfection by immersion and spraying could be effective in reducing the chances of cross-infection, compliance by dental offices/clinics has been uneven as these procedures could be seen as additional time-consuming process [9]. One of the neglected parts of impression-making is how they are handled post-procedure, specifically while they are being prepared for transfer to the laboratory. This is especially true in our part of the world. Prevention of contaminated dental impressions leaving the immediate chairside could be an ideal way to control cross-infection. This may be achieved when disinfectants are incorporated within the impression material, either in the alginate powder or in the mixing liquid. This has resulted in the development of self-disinfecting hydrocolloid impression materials where incorporation of disinfectants into the hydrocolloid powder or mixing water provided an effective means of additional decontamination [10-12]. Materials like chlorhexidine, iodophores, and quaternary ammonium compounds have been used as disinfectant additives [9]. The disinfectant is impregnated into the powder of impression material for most self-disinfecting alginates, and few attempts have been made to add disinfectants into the mixing liquid. It is also important that the time taken by the alginate-disinfectant admix to set remains within a clinically acceptable level so that it can be used in clinical practice.

In this study, mixing disinfectant liquids with alginate powder was done to understand the feasibility of this technique for the setting time, one of the important properties of impression material. This study was carried out to investigate and compare the time taken by alginate to set when chlorhexidine and povidone iodine were used as mixing liquid compared to water.

METHODS

This in vitro experimental study was conducted at the Department of Prosthodontics, College of Dental Surgery, BPKIHS, after obtaining ethical clearance from the Institutional Review Committee of BPKIHS, Dharan (IRC/2230/022). The duration of the study was one year. The sample size for the study was calculated based on previous literature by Wang et al [13]. The total sample size was calculated using the mean difference formula with a confidence interval of 95% and a power of 80%. Based on the calculation, 23 samples in each group were enrolled. Therefore, the total sample size was 69, which was divided into three groups based on the liquid used for mixing alginate (Zelgan 2002, Dentsply). The three groups were alginate mixed with water, 1% povidone iodine (Aryadine, 0.1% w/v iodine), and 0.1% chlorhexidine (Aryahex). The entire procedure was done at room temperature between 18-21°C.

The setting time was recorded following ADA specification no 18 [14]. A ring, 3 cm inner diameter and 16 mm high, was placed on a flat surface. The mixed alginate material was overfilled on the ring. The excess material was struck off level with the top of the ring by a spatula used for mixing. The flat end of a polished rod of poly methyl methacrylate, 6 mm inner diameter and 10 cm long, was placed in contact with the exposed surface of the alginate and immediately withdrawn. This contact was repeated at 10-second intervals until the end of the rod cleanly separated from the alginate. The time from the start of the mix to the time when alginate did not adhere to the end of the rod was recorded using a stopwatch.

The setting time for all samples from three groups was recorded; those data were entered in Microsoft Excel 2016 and converted into Statistical Package for Social Science (SPSS) version 20.0 for statistical analysis. The setting time in different groups were described in terms of mean, standard deviation (SD) and standard error of mean. The difference of means of setting time in between the groups were analyzed by using one way ANOVA and post-hoc tests. The probability of significance was set at 5% level of significance (95% confidence interval).

RESULTS

The mean (SD) setting time in seconds for alginate when mixed with water, when mixed with 1% povidone iodine, and when mixed with 0.1% chlorhexidine group were 132.61(1.30), 196.70 (2.80), and 264.09 (2.043), respectively. The chlorhexidine group had the longest mean setting time, while the water group had the shortest **(Table 1).**

The normality of data was checked using the Kolmogorov-Smirnov test, which showed normal distribution. Therefore, the comparison of setting time in three different groups was done by one-way ANOVA**(Table 2)**, which showed statistically significant differences in setting time between the water group, 1% povidone iodine group and 0.1% chlorhexidine group ($p < 0.05$). The post-hoc pairwise comparison of setting times between groups, revealed statistically significant differences between all the pairs ($p<0.01$) **(Table 3).**

Table 1: Descriptive statistics, means, and standard deviations for different groups

Group	N	Mean (sec)	S.D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
Water	23	132.6	1.28	0.27	132.05	133.15	129	134.4
1% Povidone Iodine	23	196.8	2.68	0.56	195.64	197.96	193.2	200.4
0.1% Chlorhexidine	23	264.02	2.06	0.43	263.13	264.91	259.8	267
Total	69	197.81	54.09	6.511	184.81	210.79	129	267

Table 2: One-way ANOVA for setting time between three groups

Group	Sum of Squares	df	Mean Square	F	p
Between Groups	198646.001	2	99323.02	22825.47	<0.001
Within Groups	287.13	66	4.31		
Total	198933.18	68			

Table 3: Post-hoc test (Tukey test) for pair-wise comparison of different groups for setting time

Group	Group	Mean Difference	Std. Error	95% Confidence Interval		p
				Lower Bound	Upper Bound	
Water	1% Povidone iodine	-64.20*	0.61	-65.67	-62.72	<0.001
	0.1% Chlorhexidine	-131.41*	0.61	-132.89	-129.94	<0.001
1% Povidone iodine	Water	64.20*	0.61	62.72	65.67	<0.001
	0.1% Chlorhexidine	-67.21*	0.61	-68.69	-65.74	<0.001
0.1% Chlorhexidine	Water	131.41*	0.61	129.94	132.89	<0.001
	1% Povidone iodine	67.21*	0.61	65.74	68.69	<0.001

DISCUSSION

An ideal impression material should produce an accurate impression, have a consistency that is dimensionally stable to resist tearing, set within a reasonable amount of time, demonstrate biocompatibility in the oral environment, and have a reasonable cost [15]. Among various impression materials introduced in dentistry, alginate impression material was used for the present study as it is a widely used and accepted impression material due to its advantageous properties, like detailed reproduction of the mouth, easy impression making techniques, and low cost [2,3].

Spray and immersion are the two most widely used disinfection techniques for alginate impression material [8]. These disinfection techniques only provide surface disinfection. Spraying of disinfectant solutions after impression making may restrict the effectiveness of disinfection, particularly for the porous hydrophilic hydrocolloids, where microorganisms can penetrate through the body and survive in the impression [16]. Disinfection by immersion may lead to dimensional changes in alginate impression material owing to its hydrophilic nature and imbibition property, and might have a direct effect on the resulting prosthesis [17].

The difficulties associated with disinfecting alginate have resulted in self-disinfecting alginate, where disinfection can be carried out by incorporating disinfectant within the powder on a manufacturer level or by directly mixing disinfectant liquid with alginate powder instead of water [9]. Studies have shown that this technique demonstrated better dimensional accuracy than spray and immersion techniques, and saved disinfection time [18,19]. One of the main advantages is the uniform distribution of the disinfectant agent throughout the structure, not just on the surface [20]. A study by Casemiro et al. suggested that the use of chlorhexidine solution for manipulation of irreversible hydrocolloids was better than the incorporation of chlorhexidine in the powder in terms of reducing the contamination presented by the impressions [21].

In this study, alginate powder was mixed with disinfectant liquids to understand the feasibility of this technique regarding an important property of impression material, i.e., the setting time. Chlorhexidine gluconate solution and povidone iodine solution were selected for this study as a substitute for water, because they are biocompatible and do not affect the physical or mechanical properties of the irreversible hydrocolloidas reviewed in previous studies [9, 22].

Most commonly used concentrations of chlorhexidine solutions as mouth rinses are 0.12% and 0.2%; these concentrations were proved to be effective against most of the microbes [23]. The recommended concentration for chlorhexidine solution to produce the self-disinfecting impression material was 1.0 g/L according to a study [13]. Considering the potency and broad-spectrum antimicrobial activity, good safety profile, and low financial cost, it seemed reasonable to use povidone-iodine as a disinfectant [16,24]. The concentration of both disinfectant solutions used in this study offers safe and effective levels of antimicrobial activity.

In the assessment of the setting time of the test specimens, it was observed that the setting time was prolonged when 1% povidone iodine and 0.1% chlorhexidine were used to mix the alginate powder. This is in agreement with the study conducted by Ramer et al. [10], Nema [12], Mathew and Sonune [25], and Alaman et al. [26]. The concentration of disinfectants used in these previous studies was 0.05% and 0.1% iodine and 0.1% and 0.2% chlorhexidine. Although the setting time in our study was observed to be prolonged, it was still within the clinically acceptable range according to established standards of the ADA Specification. No. 18, which allows a time up to 4.5 minutes for regular set impression materials [14].

Gelation of irreversible hydrocolloid impression materials occurs clinically when approximately 10% of alginate carboxyl groups are cross-linked with calcium ions [26]. The increase in setting time may be due to the delay in the supply of calcium ions required for the gelation. Povidone, polyvinylpyrrolidone, is a polyvinyl polymer of different chain lengths synthesized from acetylene and is used as a suspension or dispersion medium and volume expander [27]. This property of the disinfectant solution might have increased the gelation time during mixing with the alginate powder.

However, the result of the study conducted by Khadeer et al. [8] and Wang et al. [13] indicated no significant difference in setting time when chlorhexidine solutions were mixed with irreversible hydrocolloid impression material. In other studies, Nema [12] and Rosen and Touyz [18] found that the setting time of alginate mixed with chlorhexidine (0.5% and 0.2%, respectively) was less than alginate-water mix.

Setting time is an important property for working with irreversible hydrocolloid impression material, but it is liable to be influenced by variable factors, including water temperature, relative humidity, and mixing duration [8]. This might have been one of the reasons for the differences in setting time in different studies. Indrani et al. reported that water temperature between 13°C–28°C with a difference of 2.5°C produced significant differences in alginate setting time; the lower the water temperature being used, the longer the setting time was produced [28].

Moreover, the setting time differences might also have been contributed by the type of alginate (normal set/ fast set), room temperature, and/or retarder concentration contained in the alginate, since retarder concentration may vary in every alginate with a different trade name [28]. Irnawati et al [29] reported that the room temperature had a high contribution and a predictor for initial setting time of alginates (0.74% for normal set alginate and 0.88% for fast set alginate) and for every 1°C room temperature increase, 5.5 seconds (normal set) or 5.6 seconds (fast set) initial setting time reduction of alginate impression materials was observed. Halim et al [30] reported that variation in the composition of alginate influences the setting time, and incorporation of calcium sulfate hemihydrate produces faster setting. Lemon et al [31] studied the working and setting time of irreversible hydrocolloid impression material after adding a retarder (1 to 8 drops of sodium phosphate) and concluded that there were longer setting and working times.

However, our study has some limitations. The present study was an in vitro study, so the effect of the natural oral environment, saliva, and sulcular fluids could not be considered. The temperature and humidity were different from those of the oral cavity. The pH of the mixing liquid was not tested in our study. The difference in setting time between the normal set and fast set alginate was not investigated. The concentration of retarder in the alginate was not taken into consideration. Hence, more studies simulating the oral environment, considering the type of alginate, pH of disinfectant solutions, and retarder concentration of the alginate, are required in the future.

CONCLUSION

Alginate impression material takes more time to set when mixed with disinfectant solutions like 1% povidone iodine or 0.1% chlorhexidine than when mixed with water. Though the setting time is prolonged with the use of these disinfectants, it is within the clinically acceptable range according to established standards. The findings of this study suggest that when making dental impressions, alginate impression material mixed with 1% povidone iodine or 0.1% chlorhexidine should be held in the mouth for an additional 1 minute and 2 minutes, respectively, beyond the time recommended by the manufacturer. However, the longer setting time of these disinfectant solutions may not make it suitable to use in patients with a gag reflex and physically and mentally challenged patients who may not cooperate for a long procedure.

Within the limitations of our study, this study suggests the use of 1% povidone iodine and 0.1% chlorhexidine as a mixing liquid for alginate impression material. Setting time is concerned with the patient's gag reflex. Therefore, necessary precautions should be taken while using these disinfectant solutions, especially on sensitive patients.

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