

Dimensional Stability of Casts Derived from Three Types of Alginate at Different Times After Impression

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Abstract

Objective: To evaluate the dimensional changes in three types of alginate following three different delay times after casting. **Material and Methods:** In this laboratory study, a maxillary arch-shaped stainless steel model was prepared and three pins with similar and determined diameters and heights were placed (one at mid-line and two on the underside of the model) as reference points to compare the dimensional stability of the three types of alginates. A special metal tray was made from the main model. The main model was imprisoned by the metal tray, and these were kept for a specific time in a humid environment. Gypsum Type 4 was poured over the impression to obtain 90 gypsum casts for three types of alginate. The dimensions of casts obtained from each alginate were compared in two lateral and anterior-posterior dimensions, they were compared with each other, and the alginates were also compared to the main model.

Results: At a time interval of 15 minutes, the dimensional accuracy of the casts obtained from the three types of alginates, with the main model in both anterior-posterior and transverse dimensions was not significantly different ($p < 0.05$); but there was a significant difference at 60 minutes and 24 hours in both dimensions ($p < 0.05$). Although there was no significant difference between the alginates in both dimensions and all three studied time periods, the least difference with the main model was related to Zhermack and the highest difference was related to Golchai alginates. Pairwise comparisons showed that none of the samples had a significant difference in terms of dimensions. **Conclusion:** The dimensional stability of alginate was a time-dependent type of alginate and had no significant effect on the dimensional accuracy of casts.

Keywords: Dimensional Measurement Accuracy; Dental Impression Materials; Alginates.

Introduction

A lot of research had been carried out to improve the performance of dental sealing materials that have been used to mold hard and soft dental tissues. Different types of impression materials are available today and newer materials are also being introduced on a regular basis with the advancement of knowledge. Hence, the variety of impression materials and importance of achieving a precise mold in indirect restorations had made it necessary to select a superior material [1].

The material used for impression must have the accuracy to record the texture and should possess a proper dimensional stability [1]. Nowadays, due to its advantages over other impression materials being used in many dental procedures, alginate was considered as a selective impression material. Along with these benefits, the mold resulting from this substance was prone to dehydration and distortion due to hydrocolloid. Hence, it was recommended that alginate mold should be spilled out of the patient's mouth as soon as possible after its removal [1-3].

Previous study evaluated two extended storage alginate samples with a typical Jeltrate plus alginate sample to evaluate dimensional stability of irreversible hydrocolloids during time delay and it was observed that there was a big difference between the dimensional stability of three materials – which was both a function of material and time of impression – and there was also a difference between the two extended pour alginates [4].

The dimensional stability of the two extended pour alginates (Kromopan and Triphasix), two common types of allogeneic (Kromatic and Jeltrate), and vinylic polysiloxane (VPMIX) was evaluated and it was verified that all alginates exhibit significant dimensional changes after 24 hours and 100 hours. However, Triphasix alginate (100 hours alginate) and Jeltrate (normal) showed more stability than other samples after 100 hours and their dimensional changes ranging from 1.53-6.73% in 100 hours [2]. It was demonstrated that although extended alginates tend to produce larger casts and conventional alginates create smaller casts, impressions taken by both types of alginate could create acceptable casts even on the 5th day after impression, if kept in good condition [3].

The dimensional stability of alginate depends on both – material and time and only two, Alginoplast and Zhermack groups were comparable to the main model after 24 hours of delay in impression. Only casts that could be obtained from Zhermack had acceptable accuracy after 72 and 120 hours [5]. The dimensional stability of two types of alginates was compared and it was showed that the accuracy of casts derived from these types of alginate was different and time had no significant effect on the accuracy of gypsum casts [6].

These studies considered time to be the most important factor affecting the dimensional stability of the alginate. For reasons such as the inaccessibility of the laboratory and the desire of most dentists to transfer the mold to the laboratory, there would inevitably be a delay between the removal of the alginate mold from the patient's mouth and pouring of its cast. On the other hand, another delay was mainly due to the technician's ignorance in laboratory in terms of rapid impression of the mold. These factors together could result in dimensional changes in the obtained mold and inadequate reproduction of the resulting restorations in the oral environment. As a result,

the costs of failure of prosthetic treatments due to the inaccuracy of rehabilitation, lack of knowledge of dentists and laboratory technicians in terms of importance of the dimensional changes resulting from the delay in the transfer of the mold to the laboratory and, the rapid pouring of the mold in laboratory justifies this research project.

Many manufacturing companies of foreign alginates claimed that their products had been stable for very long periods of up to 100 minutes (1 and 2). Therefore evaluation of Iranian alginates with the existing standards of ADA and ISO and their comparison with foreign versions seems to be necessary due to production of this substance in the country and the acceptance by dentists and economic reasons. With respect to the importance of dimensional stability for alginate impression materials and the lack of sufficient research in terms of comparing the dimensional stability of domestic and foreign samples, the stability of three types of alginates were compared in this study for three times – 15 minutes, 1 hour, and 24 hours after impression.

Material and Methods

In this laboratory study, 90 gypsum cast samples were prepared which were classified into 9 groups based on the type of alginate and impression time. A stainless steel model was used as the main model (control group) which was designed as a maxillary arch. Three circular pins with the same diameter and height were placed at the approximate location of the first molars of the two sides, (P = P2P1) and the central incisors midline (A) as reference points to examine the dimensional changes.

The alginates in this study were Alginoplast (Heraeus Kulzer, Hanau, Germany), Hydrogum 5 (Zhermack, Badia Polesine, Italy) and Golchai (Iraalgin, Golchay, Tehran, Iran). Firstly, a specific tray was made consisting of self-cure acrylic (Resin Megatray, Megadenta, GmbH, Germany) and two layers of Base Plate wax (Modeling Wax, Dentsply Sirona, York, PA, USA), high stability with a diameter of 1 mm in place of A, P2, and P1 pins and a wax layer in other areas to create the necessary space for the impression material from the main model for impression. Then three impression iron-made trays were created from the acrylic tray by using industrial impression method. All impression was done by metal tray using anatomic method by one operator and under the same conditions.

According to the manufacturer's order, the proper amounts of each alginate were mixed for impression and it was created in a conventional manner. Fifteen seconds of rinse time with cold water was considered for each mold to maintain similar conditions and wipes were used for storage of molds during the time between the impression and pouring of the mold in plastic bag. Time of pouring of each mold was recorded on a label which was stuck on it. Storage of molds was maintained at room temperature and the desired time intervals with minimum temperature fluctuations. Molds were poured onto a vibrating machine at specified times using Die Stone Type IV (Prevest Denpro Ltd., Jammu, India). In all the samples, gypsum cast was removed from the molds one hour after pouring of gypsum. Casts were stored in a dry and humid environment and at room temperature in order to reduce the effect of the storage environment.

Three delays at 15 minutes, 1 hour, and 24 hours and 10 molds for each interval were considered in order to apply the effect of time on the dimensional stability of molds obtained from each alginate. A total of 90 samples and 3 groups of type of alginate and 3 time delays were studied. Two measurements were done for each sample, P1A (Posterior-Anterior) distances, which was the distance of the outer diameter of the rod P1 from the outer diameter of pin A and; P1P2 (cross-arch), which was the distance between outer diameter of P1P2 pins in order to evaluate dimensional changes of the casts in the desired time intervals.

At first, the desired distances were measured on the main model by an operator using micrometers with a precision of 1 micron and these were recorded as control group sizes. Then the same intervals were also measured on the studied casts which were categorized and coded according to type of alginate and studied time, and the obtained sizes were recorded in microns. Digital micrometers are a tool for measuring length with high precision. The precision of the micrometer was far more than the calipers. The micrometer was composed of several parts – fixed jaw of micrometer, calibrated cylinder or scale of micrometer, calibrated shell or arc Vernier of micrometer which was used for holding the micrometer. The lever at the end of the micrometer locked during measurement.

Data Analysis

The information required by the two main parts of the research – the variation of the dimensions of the existing cast in each group and its relation to the time of impression, and the type of alginate was collected, and analyzed using IBM SPSS Statistics for Windows Software, version 20 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to calculate the mean and standard deviation and ANOVA with repeated measures. A P-value <0.05 was considered to be statistically significant.

Results

According to Tables 1 and 2 at 15 minutes, the mean changes between AP1 and main model and also between P1P2 and main model showed that these distances had increased in the casts obtained from all three triglycerides compared to the control group and this difference was higher in casts obtained from Golchai and was lower in Zhermack but these did not have a significant difference with the main model ($p>0.05$).

According to Tables 1 and 2 at 60 minutes and 24 hours, the mean changes between AP1 and main model and also between P1P2 and main model showed that these distances had decreased in casts obtained from all three triglycerides compared to the control group and this difference was lower in Zhermack and higher in casts obtained from Golchai than other alginates compared to the main model. In these two periods, the mean difference between AP1 and P1P2 in all samples was statistically significant ($p<0.05$).

Table 1. The mean of dimensional changes in the AP1 distance from the main model in terms of time and type of alginate.

Alginate's Type	Average Dimensional Changes (mm)		
	15 min	60 min	24 Hours
Zhermack	0.024 ± 0.023 p = 0.31	-0.074 ± 0.025 p = 0.005	-0.076 ± 0.027 p = 0.007
Alginoplast	0.053 ± 0.023 p = 0.127	0.107 ± 0.025 p = 0.001	0.112 ± 0.027 p = 0.001
Golchai	0.059 ± 0.023 p = 0.064	0.115 ± 0.025 p = 0.001	0.121 ± 0.027 p = 0.001

Table 2. The mean of dimensional changes in the P1P2 distance from the main model in terms of time and type of alginate.

Alginate's Type	Average Dimensional Changes (mm)		
	15 min	60 min	24 Hours
Zhermack	0.0063 ± 0.023 p = 0.78	-0.097 ± 0.025 p = 0.001	-0.0107 ± 0.25 p = 0.001
Alginoplast	0.04 ± 0.023 p = 0.085	-0.134 ± 0.025 p = 0.001	-0.0148 ± 0.25 p = 0.001
Golchai	0.051 ± 0.023 p = 0.131	-0.151 ± 0.025 p = 0.001	-0.169 ± 0.25 p = 0.001

Based on the results obtained from Table 3, it could be stated that it was determined in all three time periods, and in transverse and anterior-posterior dimensions in pairwise comparison of samples obtained from three alginates that none of the samples had significant differences in size ($p > 0.05$) even though the alginate variations of the Zhermack had the lowest value compared to the main model than the two other alginates.

Table 3. Results of pairwise comparisons between alginates in terms of time.

Time		Zhermack	Alginoplast	Golchai	Distance
15 Min	Zhermack	1	0.21	0.13	AP1
		1	0.41	0.057	P1P2
	Alginoplast	0.21	1	0.78	AP1
		0.21	1	0.64	P1P2
	Golchai	0.13	0.78	1	AP1
		0.057	0.64	1	P1P2
60 Min	Zhermack	1	0.15	0.11	AP1
		1	0.15	0.4	P1P2
	Alginoplast	0.19	1	0.78	AP1
		0.15	1	0.49	P1P2
	Golchai	0.11	0.78	1	AP1
		0.4	0.49	1	P1P2
24 Hours	Zhermack	1	0.18	0.097	AP1
		1	0.11	0.18	P1P2
	Alginoplast	0.18	1	0.74	AP1
		0.11	1	0.39	P1P2
	Golchai	0.097	0.74	1	AP1
		0.18	0.39	1	P1P2

Tukey and LSD tests.

Discussion

Alginates are one of the most commonly used dental materials and this could be due to the presence of characteristics such as biocompatibility, hydrophilicity, low cost, ease of use and desirable properties during application [7]. One of the important features that were important when using these materials was the dimensional stability of the mold made from the patient's mouth, which has nowadays become one of the challenges of using these materials. The properties of this material could be influenced by time and type of alginate.

Based on the results of the present research, all three types of studied alginate impression materials showed some degrees of dimensional change compared to the main model at the studied times and these dimensional changes are time-dependent. Despite the effect of type of alginate substance, this effect was not significant. No significant difference was observed in comparison of dimensions of casts with the main model in 15 minutes and as a result, casts obtained from all three types of alginate in both directions had a precise accuracy in this interval and could be used as the final cast in fixed prosthetics for the construction of bridge and crown [8].

Impression after 1 hour, dimensions of casts obtained from all three alginates in both anterior posterior directions (AP1) and transverse (P1P2) were smaller than the main model which shows contraction of alginate in this interval. Also, dimensional changes of casts obtained from all three alginate at this time interval shows a significant difference with the main model ($p = 0.001$). According to the results of this study, dimensional changes and contractions of casts in different directions had been non-homogeneous for alginates in a way that mass contraction and as a result of the dimensional changes in transverse direction of P1P2 had been more than AP1, which was in line with the results obtained from previous research [9].

Restriction of the initial expansion of alginate mass by the walls of tray would lead to greater effect of forces of tenderness of alginate contraction and this effect in posterior direction of tray was due to simultaneous effect of lateral walls on the anterior part [9]. Dimensional changes of the casts obtained from all three alginates in both, AP1 and P1P2 showed significant differences with the main model after 24 hours ($p = 0.001$). Four different alginates (Hydrogum 5, Alginoplast, Cavex Ca37 and Jeltrat) were evaluated in four continuous periods of 24, 72 and 120 hours and it was determined that only casts obtained from two groups of Alginoplast and Hydrogum 5 were comparable to the main model and these findings were also shown in the present study [1].

A previous study evaluated dimensional stability of two types of Golchai and Alginoplast alginates at 5, 15, 30, 60, 180 minutes after impression and it was demonstrated that the casts derived from two types of alginate, are different. The time had no significant effect on the accuracy of the casts obtained from the two samples [6], which was contrary to the results of the present study.

Another studies, one on the dimensional accuracy and the other on the stability of alginate had emphasized the immediate impression of the mold. While this was not always possible, as a result, having dimensional stability during a time delay was one of the advantages. In a research done on the best conditions and the acceptable storage time for alginate molds, the authors evaluated

time intervals of 15 minutes, 30 minutes, 1 hour, and 3 hours after impression and showed that if alginate molds are poured within 15 minutes, those could be used as final casts [8].

It has been shown that dimensional variations of the Hydrogum 5 (30 minutes, 24 hours, and 120 hours) had no significant effect on the dimensional changes of the resulting casts, if the mold was kept in a humid environment which was different compared to the results of the present study. Dimensional changes in impression materials could be due to various causes, such as shrinkage due to the synergistic property, absorption of water due to exposure to moist or high humidity environments, with a longer reversal time to the initial dimensions [10].

Different alginates (Caven Ca 37, Dentsply, Jeltra and Tlydrogum) were studied. A DAI style was used in this study for impression on which two abutments were embedded similar to a base with full layer as the main model and molds were poured in four time intervals of 5 minutes, 12 minutes, 30 minutes and 1 hour. The results showed a decrease in the distance between the reference points and this decrease was from 0.023 mm in 0 minutes to 0.0531 mm in 1 hour for Cavex alginic acid and 0.0164 mm in 0 minutes to 0.447 0.4 mm in 1 hour for Chromatic and Jeltrate and 0.0134 mm in 0 minutes to 0.125 mm in 1 hour for Hydrogum [11]. The contraction in alginate mass has also increased over time in this study and has been lower in alginate algermans than in other two types, which was in line with results obtained from the present research.

Instant castings do not show significant differences with casts made after 10 minutes, 30 minutes, and 1 hour; however, casts which were made after 24 hours, were more accurate, which emphasized the urgency of impression; this was consistent with the results of this research [11]. Many studies emphasized that alginate impression should be performed within 10 minutes or 30 minutes, and eventually an hour to obtain an accurate cast, but other studies on new brands of alginate allowed the storage of molds for longer periods [12]. In the present study, although within 60 minutes and 24 hours after the impression, Iranian golchai alginate in the direction of P1P2 had lower clinical accuracy than Zhermack and Alginoplast foreign alginates, but it could be sued to diagnostic purposes and removable partial dentures [13]. In addition, Zhermack and Alginoplast foreign alginates had acceptable clinical accuracy in both directions for 24 hours that could be used for the final mold [8].

Three types of alginates were not superior in terms of dimensional stability 15 minutes after the impression, but all three had an acceptable accuracy. Alginate mass shrinkage justifies the reduction of distances and the dimensional changes of casts. The importance of further studies on these two factors was indicated according to the results of this study – in terms of the significant role of time and type of alginate in the dimensional accuracy of final casts and the heterogeneous dimensional variations in different directions. This issue became more important since results of this study showed that the dimensional accuracy of the three types of alginate were different in different directions over time and this shows a greater effect on dimensional variations of alginate impression materials.

The vitro nature of this research and the inability to simulate all the conditions and characteristics of the environment in it (the ambient temperature of the room temperature was 25°C compared to the ambient temperature of 37°C) was one of the limitations of the study. On the other hand, the present study was designed to reduce the dissipation of molds while separating the original model by putting the least amount of effort while in the oral cavity, with the presence of the undercuts, the removal of the impression would be with distortion.

In this study, the effect of the temperature of the storage environment of the molds on their dimensional changes was not considered over time. Therefore, the necessity of conducting research with the simultaneous consideration of both factors was evident. Another limitation of this research was the method of impression that was carried out in form of free hand. In the end, it was recommended that future researches be performed at a longer time periods in comparison to the present study and clinical studies be designed, if possible.

Conclusion

There was no difference in the dimensional accuracy in the 15 minute interval between the casts obtained from the three types of impression materials with the main model, but this difference was significant at 60 minutes and 24 hours. It was determined with the pairwise comparison of the samples of the three alginates together in three time intervals and in two dimensions in which none of the samples had a significant difference in size. It should also be noted that the dimensional stability of alginate depends on time; and type of alginate does not have a significant effect on dimensional accuracy. After 24 hours, the delay of casts obtained from all three alginates showed the greatest difference from the main model.

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Conflict of Interest: The authors declare no conflicts of interest.

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