Original Article

Effects of Water/Powder Ratio of Irreversible Hydrocolloid on Dimensional Stability of Impressions

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Abstract

Background and Aim: Water/powder ratio is effective on some properties of irreversible hydrocolloid impression materials. This study aimed to determine the effects of water/powder ratio of irreversible hydrocolloid impression materials on dimensional stability of impressions.
Materials and Methods: In this in vitro experimental study, a metal model with two abutments as anchoring support for a three-unit dental bridge was used. Sixty alginate impressions were made with different water/powder ratios (control group and test group with 50% extra water). The impressions were made by acrylic trays. Alginate impressions were poured with dental stone after 15, 60 and 240 min of removal from the model. The diagonals and heights of the small and large dies as well as the outer space between the two dies were measured trice using a digital caliper with 0.01 mm accuracy, and the mean values were reported. The obtained dimensions were compared with each other and with the model. Data were analyzed by one-way ANOVA, one-sample t-test, and independent samples t-test (α=0.05).
Results: In the majority of dimensions in both the control and test groups, there was a significant difference in comparison with the metal model. The mean dimensions of casts did not show any significant difference between the two groups after 240 min ($P>0.1$).
Conclusion: Increasing the water added to alginate powder by 50% affected the dimensional stability of the resulted casts. The time interval before pouring the cast had a significant effect on dimensional accuracy of the casts.
Key Words: Dental Impression Materials, Colloids, Alginates

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Introduction

Nowadays, various types of impression materials are available. With the advancements in science, newer materials are opening their way to the markets. Alginate impression material is one of these materials that is widely used in prosthetic and other dental treatments. It has been the impression material of choice for many years. To obtain an accurate impression with this material, knowledge about all the factors that may affect the accuracy of its dimensions is important. Many studies have assessed the effect of various factors on properties of irreversible hydrocolloid materials (1-8). The delay caused in pouring the impression after its removal from the mouth is one reason for dimensional changes in the impression, adversely affecting the dimensional accuracy of the restoration (9,10). Alginates undergo shrinkage over time due to water evaporation. Many authors have investigated the effects of some ingredients on properties and storage of this impression material (11,12). In fact, one of the main controversies in fabrication of dental prosthesis is related to the dimensional changes of dental alginate impression material. Different powder and liquid mixing proportions can change the setting characteristics and impression storage. Additional water can easily evaporate and cause excessive shrinkage (9). Water/powder ratio seems to be one of the influential factors on dimensional stability of alginate impressions, which has not been fully discussed. Considering the existing controversies, the aim of this study was to evaluate the effects of water/powder ratio of irreversible hydrocolloid impression materials on dimensional stability of impressions. The null hypothesis was that water/powder ratio would have no significant effect on dimensional stability of irreversible hydrocolloid impression materials.

Materials and Methods

In this in vitro, experimental study, a stainless steel model with two abutments for a three-unit bridge was used. The model had a plate on which the metal dies were located. Dies were frustum-shaped with a round cross-section and 6° taper. A V-shaped groove similar to an existing undercut was created below the finish line near the base of one of these dies. On this plate, two guiding bars were located for vertical movement of the second part of the model (Fig. 1).

To obtain the optimal thickness of alginate impression around the die, 4-5 mm space was created by 3 layers of boxing red wax (Polywax, Izmir, Turkey). Then, a putty impression (Speedex, Asiashimi, Iran) was made from the model. The cast was poured with type III dental stone (Parsdental, Tehran, Iran). On the prepared cast, 10 acrylic special trays

Figure 1. Steel model

(Acropars, Tehran, Iran) were fabricated. The trays were perforated in a standard manner. The margins of special trays were perfectly adapted over the plate around the dies and the path of insertion was limited to one. By use of 10 special trays, 60 irreversible hydrocolloid impressions and related casts (Zhermak, Roma, Italy) were prepared. Table 1 shows the manufacturer's instructions on the preparation of alginate impression material. All casts and impressions that were defective or had voids and impressions in which the alginate was separated from the tray were discarded and repeated (Fig. 2).

Impressions were divided into two subgroups (n=30): a control subgroup with standard water/powder ratio (36 mL of water and 18 g of powder) and a test group of samples prepared with 50% extra water. Alginate was mixed with water in proper water/powder ratio under standard conditions according to the manufacturer’s instructions (mixing time as specified by the manufacturer, water temperature of 23°C, using plastic bowl and spatula). Once a homogenous mixture was achieved, it was applied onto an acrylic special tray, and impression was made without applying pressure. After 5 min, it was separated from the model with minimal strain. Then, 60 impressions were kept in a zip-lock plastic bag

Table 1. Manufacturer's instructions on preparation of alginate impression material

	Powder	Liquid	Mixing time	Working time	Setting time	Manufacturer	City, Country
Tropicalgin alginate	18 g	36 mL	45”	1:35”	2:35”	Zhermack	Roma, Italy

with a damp napkin with relative humidity of 100%. The casts in each group (n=30) were poured with dental stone (Parsdental, Tehran, Iran) in 3 subgroups (n=10) after 15 min, 60 min, and 240 min. All impressions were prepared at the same temperature and relative humidity. In this study, all the time periods were measured by a stopwatch (Junso, Tokyo, Japan).

Figure 2. Casts in the 6 subgroups

The diagonals and heights of small and large dies as well as the outer space between the two dies were measured using a digital caliper with 0.01 mm accuracy (Beijing, China) and the mean values were reported. Each dimension was measured trice at three different times. The mean of 3 measurements was calculated and analyzed. The obtained data of various groups were compared with each other and with the model. Data were statistically analyzed by one-way ANOVA, one sample t-test, and independent samples t-test at a significance level of 0.05 ($\alpha=0.05$).

Results

After comparison of the mean dimensions of the casts in the control and test groups, it was found that in the majority of dimensions in both the test and control groups, there was a significant difference in comparison with the metal model (with the exception of the small dye height). However, clinically, the percentage change of dimensions in both the control and test groups was almost the same. After a period of 15 min, a significant difference was observed in the diagonal of the large die, height of small die, and height of large die between the two groups ($P\leq0.05$, $P\leq 0.001$, and $P\leq 0.05$, respectively). After a period of 60 min, a significant difference was observed between the two groups in the diagonal of small die, height of large die, and the outer space between the two dies ($P\leq0.05$, $P\leq0.05$, and $P\leq0.01$, respectively). Table 2 indicates that there was no significant difference in the mean dimensions of the casts between the 2 groups after a period of 240 min ($P>0.1$). The dimensions in the control water/powder group did not differ significantly between 60 and 240 min; while in the test group, the difference between 15 and 240 min was not significant. It should be noted that in terms of dimensional changes after 240 min, there was no significant differences between the control water/powder and the test groups.

Tables 3 and 4 represent the results of comparison of the mean dimensions of the casts prepared from irreversible hydrocolloid impressions in two groups with standard water/powder ratio and 1.5 times of the standard water/powder ratio at different time points.

Discussion

Water/powder ratio and the storage period of impressions are the influential factors on

Table 2. Mean dimensions and percentage of change (%) and P values of casts of the 6 subgroups prepared from irreversible hydrocolloid impressions and percentage of dimensional changes compared with steel model and P values

Groups	Diagonal of small die	Diagonal of large die	Outer space between two dies	Height of small die	Height of large die
Metal model	7.58	9.86	31.43	9.90	9.75
1	7.690±0.079 (1.45) P=.002	10.143±0.095 (2.7) P=.000	31.788±0.084 (1.11) P=.000	9.773±0.034 (-1.3) P=.000	9.552±0.091 (-2.05) P=.000
2	7.711±0.066 (1.71) P=.000	10.033±0.073 (1.7) P=.000	31.767±0.066 (1.07) P=.000	9.902±0.061 (0.00) P=.920	9.357±0.94 (-4) P=.220
3	7.96±0.122 (5.01) P=.015	10.102±0.127 (2.4) P=.000	31.770±0.134 (1.08) P=.000	9.886±0.055 (-1.21) P=.445	9.650±0.088 (-1.02) P=.006
4	7.708±0.030 (1.5) P=.000	10.065±0.032 (2.02) P=.000	31.786±0.091 (1.11) P=.000	9.873±0.044 (-1.31) P=.087	9.635±0.062 (-1.21) P=.000
5	7.804±0.084 (2.9) p=.000	10.150±0.050 (2.9) P=.000	31.877±0.090 (1.39) P=.000	9.889±0.104 (-1.11) P=.746	9.635±0.113 (-1.21) P=.011
6	7.756±0.166 (2.2) P=.000	10.069±0.145 (2.02) P=.001	31.657±0.204 (0.69) P=.007	9.900±0.183 (0.00) P=1	9.621±0.124 (-1.33) P=.010

Casts prepared from alginate with standard water/powder ratio after 15 min (group 1), after 60 min (group 2) and after 240 min (group 3) and casts prepared from alginate with 1.5 times the standard water/powder ratio after 15 min (group 4), 60 min (group 5) and 240 min (group 6)

Table 3. Comparison of the mean dimensions of casts prepared from alginate with standard water/powder ratio at different storage times using independent samples t-test

Dimensions / Time intervals	Diagonal of small die	Diagonal of large die	Outer space between two dies	Height of small die	Height of large die
Time intervals of 15 min and 60 min	0.350	0.010*	0.545	0.000*	0.523
Time intervals of 15 min and 240 min	0.898	0.427	0.725	0.000*	0.026*
Time intervals of 60 min and 240 min	0.737	0.155	0.950	0.547	0.341

***Significant difference**

Table 4. Comparison of the mean dimensions of casts prepared from alginate with 1.5 times the standard water/powder ratio at different storage times using independent sample t-test

Dimensions / Time interval	Diagonal of small die	Diagonal of large die	Outer space between two dies	Height of small die	Height of large die
Time intervals of 15 min and 60 min	0.003*	0.000*	0.038*	0.660	1.00
Time intervals of 15 min and 240 min	0.383	0.933	0.086	0.675	0.754
Time intervals of 60 min and 240 min	0.427	0.114	0.006*	0.871	0.795

***Significant difference**

dimensional stability of alginate impressions. In fact, one of the major debates in fabrication of dental prosthesis is the dimensional changes of alginate impressions over time. On the other hand, water/powder ratio also affects the consistency, setting time, strength, and quality of impressions. For the dimensional stability of alginate, various standards are proposed. According to the ADA classification, dimensional changes of elastomeric impression materials should be less than 1.5% after 24 h (13). Skinner and Pomes (14) considered a dimensional change of 0.1% to be acceptable for hydrocolloids. Morrant and Elphicle (15) concluded that 0.27% dimensional change was clinically acceptable for irreversible hydrocolloids. Hollenback and Smith (16) reported a mean dimensional change of 0.104% after comparison of 5 irreversible hydrocolloids and considered their accuracy to be sufficient for clinical use. Alginate impression materials are typically recommended for prosthodontic and orthodontic purposes where the level of accuracy is perceived as less critical (17). Appleby et al. (18) considered 0.22% dimensional change as clinically acceptable. No agreement has been achieved about the maximum acceptable dimensional change for hydrocolloids so far. According to the ADA standards (less than 1.5%), the alginate used in this study has optimal dimensional stability in two dimensions among all groups. The diagonal of small die had optimal dimensional stability only in standard water/powder ratio group after a period of 15 min. The height of large die had optimal dimensional stability in the group with 1.5 times the standard water/powder ratio at three different time intervals, and the group with standard water/powder ratio showed optimal dimensional stability only at the time interval of 240 min.

According to the standards proposed by Skinner and Pomes (14) (less than 0.1%), Appleby et al, (18) (less than 0.22%) and Morrant and Elphicle (15) (less than 0.27%), in this study the height of small die in the second group (casts prepared from irreversible hydrocolloid impressions with water/powder ratio as specified by the manufacturer after 60 min) and sixth subgroup (casts prepared from irreversible hydrocolloid impressions with 1.5 times the standard water/powder ratio recommended by the manufacturer after 240 min) had optimal dimensional stability.

In a study by Dahl et al, (19) the dimensional stability of 4 types of alginates was acceptable and their dimensional change was less than 0.22% after 24 h of storage. Schleier et al, (20) in their study on irreversible hydrocolloids kept the impressions for 0, 30, 120, 180, 210 min in a humidified chamber. After comparison of diagonals and heights of the casts, no difference was observed with the original model after the time intervals. The only difference was found in the space between the two dies on the prepared casts after 180 min (P=0.02). They concluded that this type of irreversible hydrocolloid can be maintained in 100% relative humidity for 60 min. In the present study, compared to the metal model, the lowest percentage of change was observed in the height of small die after 60 min in the casts prepared from alginate with standard water/powder ratio. Also, the highest percentage of change in the diagonal of small die was observed after 240 min in the casts prepared from alginate with standard water/powder ratio. Among the three-time periods in the control water/powder groups, the outer space between the two dies and the height of small die, and in the test groups, the height of small die and the height of large die showed no significant difference. Raszewski et al, (21) in their study on the influence of water quantity on the dimensional changes during storage showed the biggest shrinkage in alginate with 15% excess water. Storage of samples prepared with +15% water for over 24 h led to 5% shrinkage for Neocolloid and 4.41% for Tulip. These results were consistent with ours.

The present study indicated changes in dimensional stability by changing the recommended water/powder ratio to 1.5 times the standard ratio at 15 and 60 min after pouring the casts. But with 1.5 times increase in water/powder ratio and after 15 min, only the height of small die was closer to that of metal model. In fact, change in water/powder ratio to 1.5 times the standard ratio did not cause a considerable change in dimensional stability of the casts prepared from alginate.

Conclusion

The present study indicated that by 1.5 times increase in the standard water/powder ratio, a significant change occurred in specific dimensions of casts after 15, 60 and 240 min time period from removal of irreversible hydrocolloid impression.

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