Dimensional Stability of Modified Alginates

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Introduction

Alginates are the most utilized impression material in the dental world. They are used to create a negative impression of the dentition of a patient in order to ultimately create a positive impression using dental gypsum products. The dental model of the dentition is then used to fabricate many dental appliances such as, orthodontic retainers, mouthguards, customized tray, etc. . Therefore, the accuracy of the original alginate impression must be high in order to produce an accurate working cast and prevent discomfort when the final appliance is given to the patient. Accuracy is said to decreases as the time between the initial impression and the pouring of the dental stone increases. In dry conditions the alginate shrinks toward the impression tray, causing the dimensions of the impressed area to increase. On the other hand in humid conditions, the alginate can swell, causing the dimensions of the impressed area to decrease. In recent years companies have proposed alginates that can be poured up to 5 days after the impression has been taken, remaining dimensionally stable if stored correctly.

When casts are poured using alginate impressions, the success of the procedure greatly depends on the accuracy and dimensional stability of the alginate material. Any shrinkage of the impression that occurs during storage time can lead to errors such as ill fitting appliances or prosthetics. For this reason, dimensional stability is a very important attribute when dental offices are choosing a brand of alginate.

Surface roughness of the alginate impression is also of great importance. An impression with excessive roughness will produce a cast that also has excessive roughness. Appliances fabricated on such casts will cause discomfort to the patient, as well as provide a site for biofilm accumulation.

The goal of this study is to assess the effect of the storage time on the dimensional stability and roughness of five alginate available on the market: three modified alginates, Hydrogum 5, Kromopan, and Blueprint, as well as two conventional alginates Jeltrate Regular Set and Hydrogum. Our null hypothesis is that there is no difference in the dimensional stability and roughness, between the three modified alginates and the two conventional alginates.

Materials and Methods

Using a dentoform (Frasaco, Tettnang, Germany) three specific distances were measured and assigned as the baseline measurements, as shown in figure 1:

i) The interarch distance (IA) was measured between holes prepped into tooth number 14 and tooth number 24 using a high speed handpiece and a 245 bur. It was found to be 32.56 mm using a set of Mituyoto (Kanagawa, Japan)calipers;

ii) An edentulous space, space for the pontic (SP), was measured between 17 and 15 and found to be 10.94 mm using the same set of calipers;

iii) The buccal lingual space (BL) width of tooth number 26 was also measured and found to be 12.16 mm.

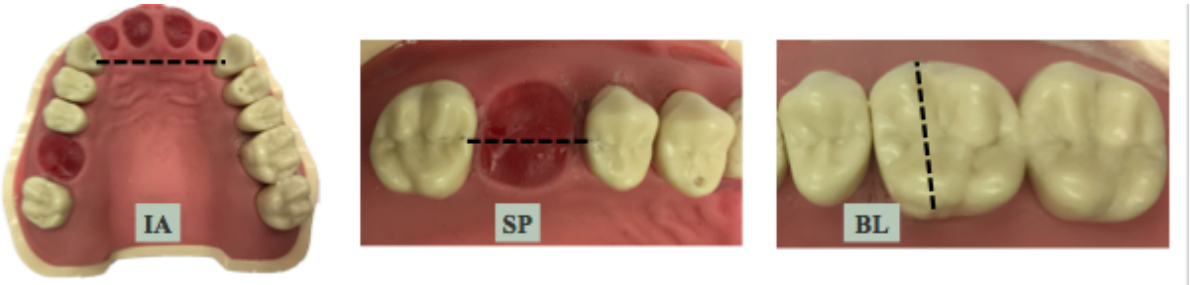

Figure 1. Dentoform showing the three different measurement areas: IA (interarch distance), SP (space for the pontic) and BL (buccal lingual space)

Five different brands of alginate impression material were used: Jeltrate Regular Set (Densply), Hydrogum (Zhermack), Hydrogum 5 (Zhermack), Blueprint (Dentsply), and Kromopan (LASCOD). These impression materials (displayed in Fig. 2) have their composition indicated in Table 1 and they were manipulated according to manufacturer recommendations,.

Figure 2. Alginates brands used in this study.

Brand	Manufacturer	Composition	Ratio W/P	Mixing time
Jeltrate	Dentsply	Potassium Alginate Diatomaceous Earth Cristobalite Calcium Sulfate Magnesium Oxide Silica Crystalline (Quartz) Tetrasodium Pyrophosphate	19 ml/8 g	60 Seconds
Hydrogum	Zhermack	Potassium Alginate Cristobalite Dipotassium Hexafluorotitanate Isopentyl Acetate	48 ml/ 24 g	30 Seconds
Hydrogum 5	Zhermack	Potassium Alginate Cristobalite Dipotassium Hexafluorotitanate Isopentyl Acetate	51 ml/24 g	30 Seconds
Kromopan	LASCOD	Diatomaceous Earth Crystalline Silica Sodium Alginate Sodium Phosphate Calcium Sulphate	53 ml/ 24 g	30 Seconds
Blueprint	Dentsply	Sodium Alginate Diatomaceous Earth Cristabalite Dipotassium Hexafluorotitanate Magnesium Oxide	51 ml/75 g	30 Seconds

Figure 3. Composition, Manufacturer W/P ratio, and mixing times of alginate brands used in this study

Jeltrate Regular Set was mixed for 60 seconds using three scoops of powder with the scoop that came with the Jeltrate, and cold tap water filled up to the 3rd line on the corresponding alginate water cup. This alginate was left to set for 2.5 minutes. Hydrogum 5 was mixed using 51 ml of cold water to 24 g of hydrogum powder, mixed for 30 seconds and setting time was 3 minutes. Hydrogum was mixed using 48 ml of cold water and 24 g of Hydrogum 5 powder, also mixed for 30 seconds and allowed to set for 2 minutes. Blueprint was mixed using 51 ml of cold water and 75 ml of Blueprint alginate powder. Lastly, Kromopan was mixed using 53 ml of cold water and 24 g of powder, mixed for 30 seconds and allowed to set for 2 minutes. When taking impressions, before the tray was placed on the cast, a small amount of alginate was placed inside the holes of the lingual cusps on 14 and 24 to ensure that these holes would be reproduced on the casts.

Impressions (n=5) were poured either immediately after the impression was taken, 1 day after, or 5 days after. When poured 1 day or 5 days after separation, the impressions were wrapped individually in a wet paper towel and kept in a sealed Tupperware container to ensure 100% humidity during storage.

Impressions were poured using Type 4 gypsum Jadestone ((Whip Mix, Louisville, KY, USA), by vacuum mixing 120 g of powder and 26 ml of water. The jadestone was then poured using vibration beginning at tooth 17 and allowing it to flow through the arch. Once the teeth were filled adequately, a base was then formed with jadestone. The pour ups were allowed to set for 30 minutes before separation, at which point they were labeled with the type of alginate used, as well as whether it was an immediate (control), 1 day, or 5 day pour up.

Dimensional Analyses:

Using a Mitutoyo calipers, the interarch distance, the edentulous space, and the buccal-lingual width of 26 were measured to the nearest 0.01 mm. The edentulous space and the buccal-lingual width were measured closely to lines made on the original cast when measuring these dimensions. The holes made on the lingual cusps of 14 and 24 were reproduced in the casts and used for that measurement.

Roughness Analyses:

Surface roughness measurements (Ra) were taken using a portable surface roughness tester (Surftest SJ-210; Mitutoyo, Kanagawa, Japan). The average surface roughness is the roughness arithmetic average from the 3 lines measured within the sampling length. The measures were taken in the same spot for all samples.

Statistic analyses:

The mean data obtained from dimensional stability test were subjected to 3-way ANOVA (factors: alginate brand name, storage time and space) and roughness average results were subjected to 2-way ANOVA (factors: alginate brand name and storage time). Also Tukey's post

hoc test at 5% significance level using Origin Lab 9 software (OriginLab Corporation, Northampton, MA, USA).

Results

Dimensional stability

The average results for dimensional stability are in Figure 3 and the ANOVA are displaced in table 3

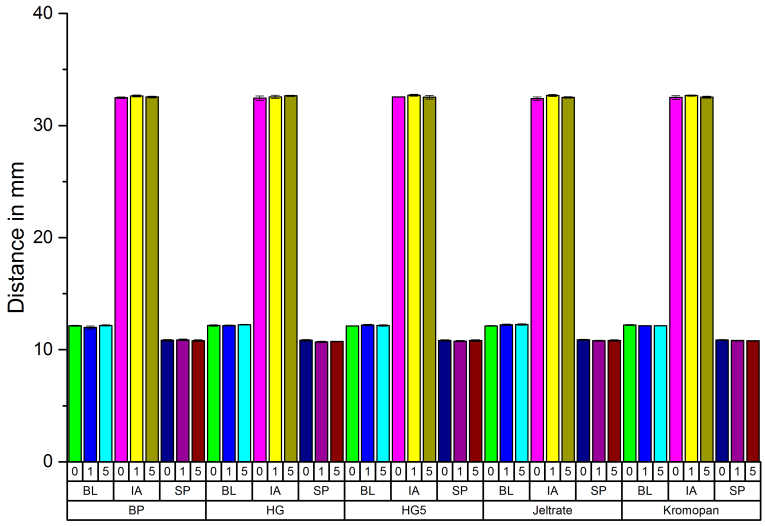

Figure 4. Averages of the alginates according the factors: space and storage time

Table 3: 3-way ANOVA results.

	DF	Sum of Squares	Mean Square	F Value	P Value
Brand Name	4	0.02808	0.00702	1.13692	0.34065
Space	2	22272.71823	11136.35912	1.80375E6	0
Time	2	0.05199	0.026	4.21063	0.01632
Brand Name * Space	8	0.16041	0.02005	3.2476	0.00177
Brand Name * Time	8	0.11831	0.01479	2.39531	0.01772
Space * Time	4	0.39881	0.0997	16.14876	2.55935E-11
Brand Name * Space * Time	16	0.23881	0.01493	2.41748	0.00257
Model	44	22273.71463	506.22079	81992.35294	0
Error	180	1.11132	0.00617	0	0
Corrected Total	224	22274.82595	0	0	0

As displayed in table 3 at α=0.05, all factors were statistical significant different, with the exception of brand name.

In order to make this difference more visible the average (R) were subtracted by the control average (Cv) and divided by the control mean (Cv) and multiplied by one hundred to have a percentage of dimensional alteration, as in the formula below:

$$DA\ (\%) = \frac{Cv - R}{Cv} x\ 100$$

The results are in the figure 4 below:

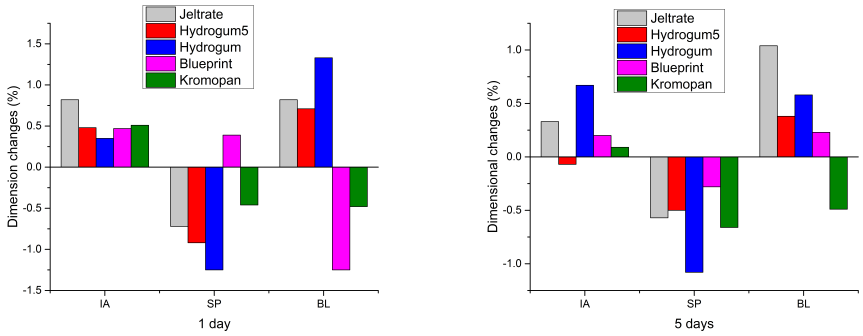

Figure 5. Dimensional alteration compared with the control group in percentage.

Analysis of the results obtained showed that dimensional change occurred after storage of the alginate impression for 1 day, as well as 5 days. Variation was shown in terms of which alginate material showed the most dimensional change. The highest amount of change was expansion by 1.25% of the BL width and shrinkage of 1.25% of the pontic space on cast poured from the Hydrogum impression that was stored for 1 days before pouring. Shrinkage of 1.25%

also occurred on the cast poured from the Blueprint impression stored for 1 day. Variation between the two storage times was apparent, with more dimensional change occurring in impressions stored for 1 day than those stored for 5 days.

Roughness test:

The average results for roughness are in Figure 5 and the ANOVA are displaced in table 4

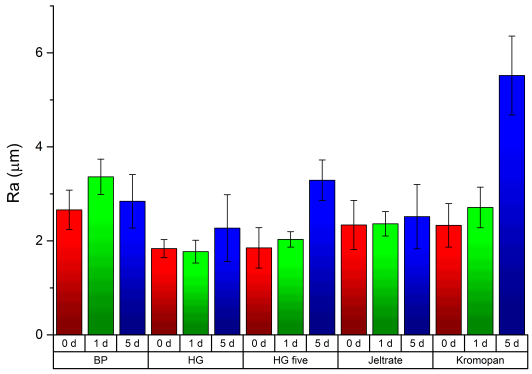

Figure 6. Average results for roughness test of the five alginate according to the storage time.

Table 4. 2-way ANOVA results

	DF	Sum of Squares	Mean Square	F Value	P Value
Alginate	4	26.18232	6.54558	27.65187	4.08562E-14
Time	2	19.43058	9.71529	41.04233	9.11604E-13
Interaction	8	26.96672	3.37084	14.24015	2.13329E-12
Model	14	72.57962	5.18426	21.90095	0
Error	75	17.75354	0.23671	--	--
Corrected Total	89	90.33316	--	--	--

All factors and the interactions were significantly different at at α=0.05. In terms of roughness, casts poured from HG5 and Kromopan impressions stored for 5 days showed the highest surface roughness .

Discussion

The accuracy and dimensional stability of an alginate impression must be high in order to produce an accurate working cast and prevent discomfort when the final appliance is delivered to

the patient. In this study, we tested the dimensional stability of 5 different alginate brands using dimensions that were premeasured on a dentalform and compared to the same dimensions on casts poured from the various alginate impressions.

Our null hypothesis was denied by the results of our study. There was a difference in the dimensional stability of the different alginate brands, with some showing more dimensional changes than others. One reason for this could be that water as a storage medium does not react with the alginate but is taken into the impression through imbibition, or evaporated from the impression though synerhesis.

The largest amount of dimensional change was 1.25% of shrinkage, as well as 1.25% of enlargement in the casts poured from a Hydrogum impression stored for 1 day. This amount can be considered negligible considering the type of appliances that are made using alginate impressions exclusively. For example, orthodontic appliances can be adjusted to fit the patient even if 1.25% dimensional change occurs in the impression used to fabricate them. Whereas fixed prosthetic appliances such as crowns or bridges are more difficult to make changes to once they are fabricated if any dimensional changes affect their seating in the patient.

Surface roughness of a cast used for study models has little importance in comparison to casts used to fabricate appliances used for orthodontics, mouth guards, or partial denture prostheses. Any roughness present on the cast poured from an alginate impression will be transferred to the resulting appliance. This can increase the need for polishing and excessive polishing can lead to an ill fitting prosthesis.

For future studies, prevention of human error can yield much more accurate results. A mechanical alginate mixer can be utilized to provide a standard mixing time to all alginates used. Inadequate mixing time can affect the chemical reaction involved in the setting of the alginate impression. A mechanical mixer can also minimize the amount of powder or water that spills out of the bowl during mixing. This can help avoid changes in the W/P ratio and eliminate these changes as a possible reason for dimensional changes. Past studies have used a stainless steel dentoform rather than a silicone and plastic dentoform for their impressions. Although the stainless steel will result in less movement of the dentition, this is not desired because a plastic dentoform can more closely emulate the natural movement that occurs within a patient.

The clinical relevance of this study is due to the commercial appeal that these modified alginates can be poured up to 5 days from the time that the impression was taken. This would be

beneficial in a busy clinic where immediate pouring of impressions may not be possible. However based on the results of our study this is not a good attitude. The recommendation would be to pour the impression as soon as possible to avoid dimensional changes and increased roughness.

Conclusion

With the limitations of this study our results have shown significant statistical difference among the five studied alginates. All alginates underwent dimensional variations after storage. Kromopan was shown to cause expressive increasing of the casts roughness after 5 days of storage.

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