LINEAR DIMENSIONAL STABILITY OF IRREVERSIBLE HYDROCOLLOID MATERIALS OVER TIME

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ABSTRACT
The aim of this study was to evaluate the linear dimensional stability of different irreversible hydrocolloid materials over time. A metal mold was designed with custom trays made of thermoplastic sheets (Sabilex, sheets 0.125 mm thick). Perforations were made in order to improve retention of the material. Five impressions were taken with each of the following: Kromopan 100 (LASCOD) [AlKr], which has dimensional stability of 100 hours, and Phase Plus (ZHERMACK) [AlPh], which has dimensional stability of 48 hours. Standardized digital photographs were taken at different time intervals (0, 15, 30, 45, 60, 120 minutes; 12, 24 and 96 hours), using an "ad-hoc" device. The images were analyzed with software (UTHSCSA Image Tool) by measuring the distance between intersection of the lines previously made at the top of the mold. The results were analyzed by ANOVA for repeated measures. Initial and final values were (mean and standard deviation): AlKr: 16.44 (0.22) and 16.34 (0.11), AlPh: 16.40 (0.06) and 16.18 (0.06). Statistical evaluation showed significant effect of material and time factors. Under the conditions in this study, time significantly affects the linear dimensional stability of irreversible hydrocolloid materials.

Key words: *Dimensional measurement accuracy; alginates.*

DETERMINACIÓN DE LA ESTABILIDAD DIMENSIONAL LINEAL DE HIDROCOLOIDES IRREVERSIBLES

RESUMEN
El objetivo de este estudio fue evaluar la estabilidad dimensional lineal de diferentes hidrocoloides irreversibles en función del tiempo. Se confeccionó una matriz metálica con sus correspondientes cubetas individuales realizadas con láminas termoplásticas (Sabilex, de 0.125 mm de espesor). Se le realizaron perforaciones para la retención del material. Se tomaron cinco impresiones con cada material a esta matriz, utilizando Kromopan 100 (LASCOD) [AlKr], que presenta una estabilidad dimensional de 100 horas, y Phase Plus (ZHERMACK) [AlPh], que tiene una estabilidad dimensional de 48 horas. Luego se tomaron fotografías estandarizadas a diferentes intervalos de tiempo (0, 15, 30, 45, 60, 120 minutos; 12, 24 y 96 horas), usando un dispositivo ad-hoc. Las imágenes se analizaron con software de procesamiento de imágenes (UTHSCSA Image Tool) realizando la medición de la distancia entre las intersecciones de surcos previamente realizados en la porción superior de la matriz. Los resultados obtenidos fueron analizados mediante Análisis de Varianza para mediciones repetidas. Se detallan los datos iniciales y finales obtenidos (media y DS): AlKr: 16,44 (0,22) y 16,34 (0,11), AlPh: 16,40 (0,06) y 16,18 (0,06). El análisis estadístico ha mostrado el efecto significativo para las variables material y tiempo. Bajo las condiciones de este estudio podemos concluir que tiempo afectaría significativamente la estabilidad dimensional lineal de los hidrocoloides irreversibles.

Palabras clave: *exactitud de medida de dimensiones; alginatos.*

INTRODUCTION

Impressions of oral structures to be used for making casts are needed for various purposes, including diagnoses, rigid restorations and dental prostheses. They should be made from a material which is easy to manipulate and provides accurate replication, adequate dimensional stability and biological compatibility.

The choice of material for an impression is one of the most important steps in the process. Among the various materials available, alginate is undoubtedly one of the most frequently used, thanks to its elasticity, simple manipulation technique and low cost, among other properties.

Studies on the dimensional stability of alginate[1-5], have given special attention to syneresis and imbibition[3,6,7]. Syneresis is the loss of water by evaporation from the surface or exudation, which makes the gel to contract. Imbibition, in contrast, is the absorption of water during immersion. Both these processes alter the original dimensions of the gel and thereby its dimensional stability[6,7]. It is important to take syneresis and imbibition into account because any dimensional change that

occurs after removing the impression from the mouth will produce inaccurate pours and casts.
Manufacturers add fillers and small amounts of certain components in order to control consistency, setting time, elasticity, resistance and dimensional stability. Some alginates which have recently appeared on the market promise dimensional accuracy and stability for up to 5 days.
The literature describes different storage methods for alginate impressions during the time until the cast is made, including waiting times and standardized temperature and moisture conditions[2-5].
The aim of this study was to determine and compare linear dimensional stability of two irreversible hydrocolloids which are sold as materials with improved dimensional stability over time. We did not standardize the temperature and storage conditions of the impression until the cast was made, in order to replicate the conditions to which the materials are normally exposed during everyday use.

MATERIALS AND METHODS

Individual trays were made from 0.125 mm thick thermoplastic sheets (Sabilex) on a metal mold, following a standardized insertion path when the impression was taken (Figs.1 and 2). Perforations were made to improve retention of the material. The impressions were made with two irreversible hydrocolloid commercial brands: Kromopan 100 (Lascod, batch 161.301.119.201, expiry date 03/2014) [AlKr], for which the instructions specify that the maximum time to making the cast is 100 hours; and Phase Plus, (Zhermack batch 93131, expiry date 09/2014) [AlPh], for which the instructions specify that maximum time is 48 hours. We defined n=5 for both groups. In order to ensure precise quantities, the powders were weighed on a digital scale (Ohaus Analytical Standard) with a precision of 4 decimals, and the water was measured with a measuring cylinder. Both materials were prepared according to the manufacturers' instructions for mixing, working and gelling times. The impressions were washed for 30 seconds and stored in a hermetically sealed rigid container with cotton soaked in water apart from the samples to prevent any direct contact with the material.
A piece of metal 5 mm long was placed in each impression to calibrate the software used to measure the distances between marks. Photographs were taken of the impressions with a Sony® digital camera (model DSC-W1), using an *ad-hoc* device to standardize the impression-camera position (Figs. 3 y 4). Photographs were taken at the following time intervals: 0, 15, 30, 45, 60, 120 minutes; 12, 24 and 96 hours. For each picture, the impression was removed from the container, placed in the device and photographed within 45 seconds. The pictures were analyzed with image analysis software (UTHSCSA ImageTool Version 3.0) to measure the distance between the intersections of the grooves formed by the upper part of the mold (Fig.5). Data were analyzed statistically by ANOVA (Analysis of Variance for repeated measures for the time factor) using SPSS software version 9.0. Significance was established as $\alpha = 5\%$.

Fig. 1: Individual tray made of thermoplastic sheet.

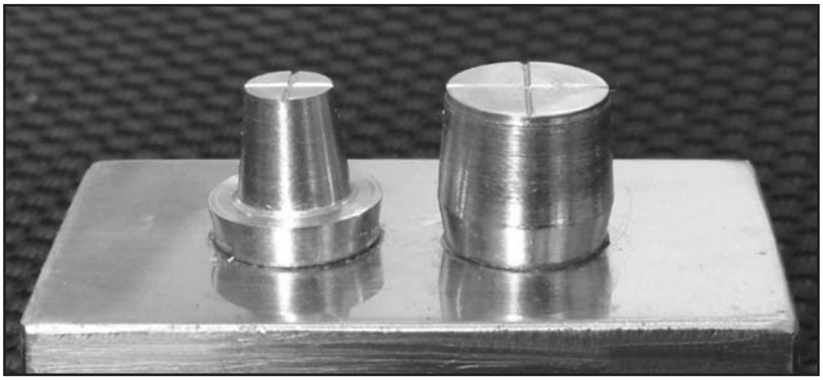

Fig. 2: Lateral view of the metal mold used as a model for taking impressions.

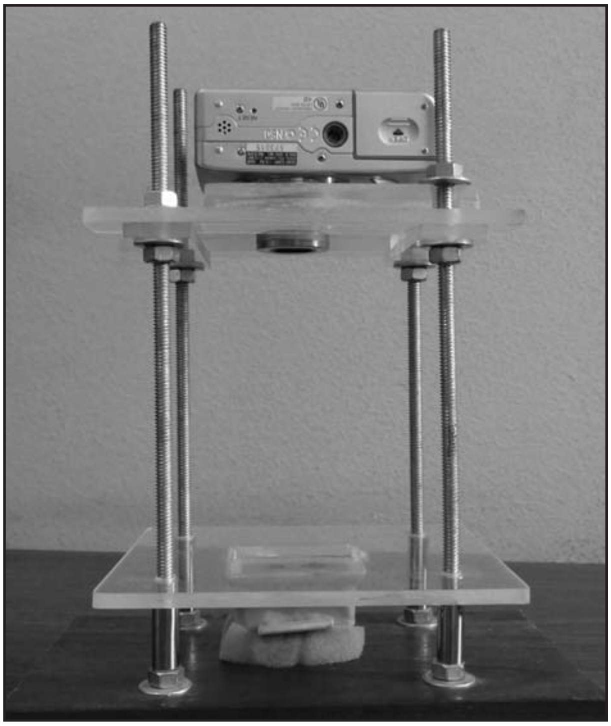

Fig. 3: Ad-hoc device for taking photographs.

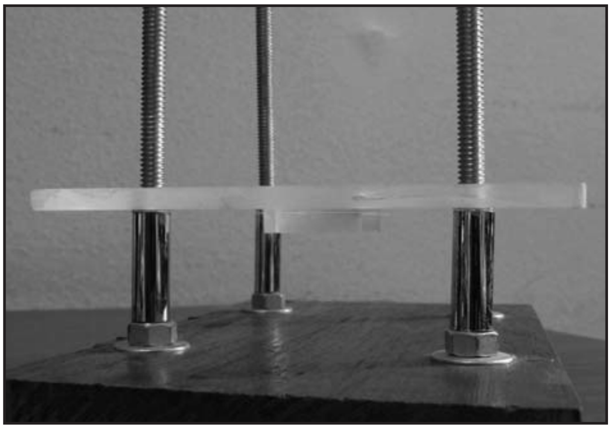

Fig. 4: Lateral view of the impression positioner in the ad-hoc device.

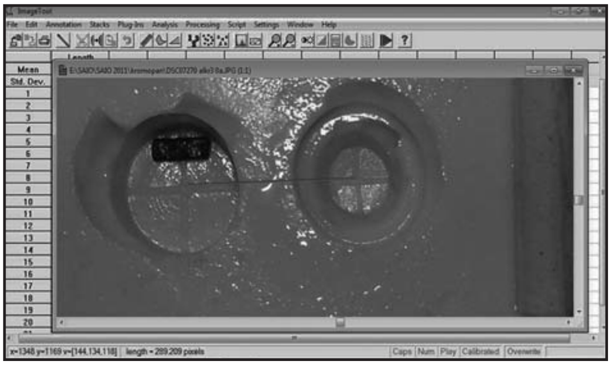

Fig. 5: Measuring with Image Tool image processing software.

RESULTS

Table 1 shows arithmetic means, standard deviations and percentage of dimensional variation for the different times compared to the first measurement taken (0 minutes). For Phase Plus, change over time was more constant (Fig. 6). Its greatest stability was observed at 15 minutes from time 0 and lowest at 96 hours. At 24 hours there was already a difference of 0.91% compared to the original measurement. However, the difference was never statistically significant (p>0.05).

For Kromopan 100, variation was not constant. It was greatest at 24 hours (0.04%) and lowest at 12 hours. At 96 hours dimensional change was 0.61% with respect to the original measurement. The difference was not statistically significant (p>0.05). Table 2 provides the result of the statistical analysis, showing that there was a significant effect for the time factor (p=0.026), and no significant effect for the brand variable (p=0.403) or for interaction between variables (p=0.264).

DISCUSSION

The literature we reviewed revealed two ways of evaluating dimensional stability of impression materials: on the impression material itself[2,3] or on the models made from an impression[1,4,5,8]. Our study recorded dimensional stability directly from the impression at different times: 0, 15, 30, 45, 60, 120 minutes; 12, 24 and 96 hours, in order to avoid any changes which might occur as a result of using other materials.

The papers by Chen[1], Bayindir[2] and Lapria Faria[8] all evaluated time intervals not longer than 24 hours, probably due to the possible dimensional changes in viscoelastic materials over long periods of time. Bayindir et al.[2] evaluated changes in

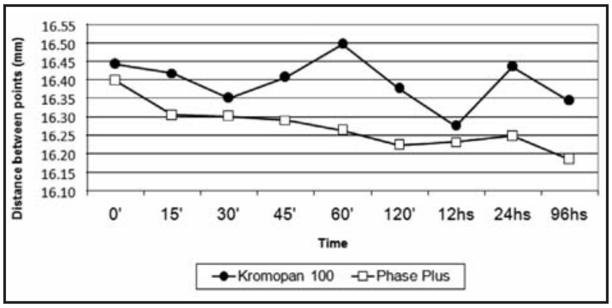

Fig. 6: Dimensional changes (in millimeters compared to baseline) recorded for each impression material (Kromopan and Phase Plus).

Table 1: Variation in size (mean and standard deviation) expressed as difference between initial and final value at each time evaluated.

MATERIAL		0 min	15 min	30 min	45 min	60 min	120 min	12 h	24 h	96 h
Kromopan 100	Mean	16.4415	16.4173	16.3488	16.4058	16.4960	16.3758	16.2733	16.4350	16.3420
	SD	0.2229	0.1468	0.0749	0.3441	0.2205	0.2353	0.2676	0.2839	0.1080
	dimensional change (%)	0%	-0.15%	-0.56%	-0.21%	+0.33%	-0.40%	-1.02%	-0.04%	-0.61%
Phase Plus	Mean	16.3972	16.3028	16.2994	16.2888	16.2620	16.2210	16.2300	16.2458	16.1834
	SD	0.0567	0.0259	0.0719	0.1269	0.1144	0.1646	0.1046	0.0810	0.0598
	dimensional change (%)	0%	-0.58%	-0.60%	-0.66%	-0.82%	-1.07%	-1.02%	-0.92%	-1.30%

Table 2: Analysis of variance. Test of Within-Subjects Contrasts.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Time	.063	1	.063	11.792	.026
material	.234	1	.234	.874	.403
Time* material	.009	1	.009	1.682	.264

temperature and pH, and variations in dimensional stability for 4 alginate brands by measuring directly under a microscope for a maximum 2 hours at 10-minute intervals, concluding that the linear dimensional changes in the four irreversible hydrocolloids differed significantly for the variable time and for the variable material.

In contrast, our study, in agreement with Walker[3], Imbery[4], and Sedda[5], evaluated dimensional accuracy over longer periods of time. Walker et al.[3] evaluated dimensional changes in three alginate brands at 30 minutes, 48 and 100 hours, showing that all materials contracted after being stored for 30 minutes, and that conventional alginate continued to contract over a longer time, and was thus most accurate at 30 minutes. In contrast, alginates with longer pouring times, Alginmax and Kromopan 100, underwent minimal dimensional changes at all storage times. Nevertheless, Kromopan 100 had the best accuracy at 100 hours. Imbery et al.[4] studied the effects of extended storage time on the dimensional accuracy of irreversible hydrocolloids (one conventional and another with extended pouring time). Their results indicate that when the manufacturer's instructions are followed, either by pouring immediately or at 5 days, both materials produced plaster casts with no significant difference compared to the master model. The material with extended pouring time was less accurate when poured immediately and at 24 hours, whereas conventional alginate was less accurate when poured at 3 and 4 days. They conclude that extended pour alginate tends to produce smaller models compared to the mold used; and that this type of alginate did not change dimensionally by more than 0.5% at any of the times at which measurements were taken. Sedda[5] et al. studied the dimensional stability of five alginate brands, over different times, on models obtained from impressions stored at constant temperature and moisture. Their results showed that the dimensional stability of the alginate impressions were material- and time-dependent.

Another variable considered in our study, which is not often found in the literature, was exposing impressions to different temperature ranges. Although this variable was not fully controlled, all impressions were taken and evaluated at the same time, so they all underwent the same conditions. These temperature changes also contribute to dimensional change, and it should be considered, for example, that a decrease in temperature produces slight contraction[6]. Our study did not control for the temperature at which the impressions were stored, because we intended to replicate usual manipulation at a dental office or laboratory. It is important to take this into account when attempting to replicate environmental conditions to which they are usually exposed while being moved to the laboratory, in order to create protocols for alginate impression manipulation and ensure that more accurate plaster casts are obtained.

Nevertheless, the lack of standardization in the techniques for evaluating hydrocolloid dimensional stability and the variability in the results found in this and other studies[9] do not enable manipulation protocols to be established. Thus, according to the type of cast that needs to be made, it is important to determine the waiting time between taking the impression and making the cast. When a cast is needed for diagnosis, small dimensional changes may not have great impact on its clinical application. However, when more accurate casts – working casts – are needed, and the storage time and/or transportation conditions and temperatures that the impression will undergo are unknown, it is advisable to pour it immediately.

CONCLUSION

Under the conditions in this study, we conclude that time may significantly affect the linear dimensional stability of alginates sold as materials with greater dimensional stability.

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