LINEAR DIMENSIONAL STABILITY OF ELASTOMERIC IMPRESSION MATERIALS OVER TIME

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ABSTRACT

The purpose of this study was to evaluate the linear dimensional stability of different elastomeric impression materials over time. A metal mold was designed with its custom trays, which were made of thermoplastic sheets (Sabilex sheets 0.125 mm thick). Three impressions were taken of it with each of the following: the polyvinylsiloxane Examix-GC-(AdEx), Aquasil-Dentsply-(AdAq) and Panasil –Kettenbach-(AdPa), and the polydimethylsiloxane Densell-Dental Medrano-(CoDe), Speedex-Coltene-(CoSp) and Lastic-Kettenbach-(CoLa). All impressions were taken with putty and light-body materials using a one-step technique. Standardized digital photographs were taken at different time intervals (0, 15, 30, 60, 120 minutes; 24 hours; 7 and 14 days), using an "ad-hoc" device, and analyzed using software (Image Tool) by measuring the distance between lines previously made at the top of the mold. The results were analyzed by ANOVA for repeated measures. The initial and final values for mean and SD were: AdEx: 1.32 (0.01) and 1.31 (0.00); AdAq: 1.32 (0.00) and 1.32 (0.00), AdPa: 1.327 (0.006) and 1.31 (0.00); CoDe: 1.32 (0.00) and 1.32 (0.01); CoSp: 1.327 (0.006) and 1.31 (0.00), CoLa: 1.327 (0.006) and 1.303 (0.006). Statistical evaluation showed that both material and time have significant effects. Conclusion: Under the conditions in this study we conclude that time would significantly affect the lineal dimensional stability of elastomeric impression materials.

Keys words: shrinkage, silicone, elastomers

ESTABILIDAD DIMENSIONAL LINEAL DE ELASTÓMEROS PARA IMPRESIÓN EN FUNCIÓN DEL TIEMPO

RESUMEN

El objetivo del trabajo fue evaluar la estabilidad dimensional lineal de diferentes elastómeros para impresión. Se confeccionó una matriz metálica con sus correspondientes cubetas individuales realizadas con láminas termoplásticas (Marca Sabilex, de 0.125 mm de espesor). Se tomaron tres impresiones con cada material a esta matriz. Se utilizaron tres siliconas por adición: Examix-GC-(AdEx), Aquasil-Dentsply-(AdAq), y Panasil –Kettenbach-(AdPa); y tres siliconas por condensación: Densell-Dental Medrano-(CoDe), Speedex-Coltene-(CoSp), y Lastic-Kettenbach-(CoLa). Se realizaron todas las impresiones utilizando dos consistencias: pesada y liviana, con la técnica de un solo tiempo. Luego se tomaron fotografías estandarizadas a diferentes intervalos de tiempo (0, 15, 30, 60, 120 minutos; 24 horas; 7 días y 14 días), con una cámara fotográfica digital, utilizando un dispositivo ad-hoc. Las imágenes se analizaron con software de procesamiento de imágenes (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. La media y el DS inicial y final para todos los materiales fue: AdEx: 1,32 (0,01) y 1,31 (0,00); AdAq: 1,32 (0,00) y 1,32 (0,00); AdPa: 1,327 (0,006) y 1,31 (0,00); CoDe: 1,32 (0,00) y 1,32 (0,01); CoSp: 1,327 (0,006) y 1,31 (0,00); CoLa: 1,327 (0,006) y 1,303 (0,006). La evaluación estadística mostró el efecto significativo de las variables material y tiempo. Conclusión: Bajo las condiciones de este estudio podemos concluir que el tiempo afectaría significativamente la estabilidad dimensional lineal de elastómeros para impresiones.

Palabras clave: contracción, siliconas, elastómeros.

INTRODUCTION

The success of prosthetic rehabilitation depends on a set of factors ranging from diagnosis to the materials used at each stage.

It is important to have knowledge not only of the clinical steps to be performed, but also of the properties of the materials, as well as any precautions or considerations they may require. Currently available impression materials provide excellent results, but they are not all capable of fully meeting the desired requirements.

The literature reports that linear contraction for condensation and addition silicones at 24 hours is 0.7 and 0.22% respectively[1].

Several factors need to be taken into account in order to minimize deformation of the impressions, including, among others: a) polymerization shrinkage, b) release of byproducts, c) contraction / expansion due to temperature changes, d) incomplete recovery of deformation due to the viscoelastic behavior of these materials, e) use of a custom tray made of acrylic resin that has not completed its polymerization and therefore still undergoes polymerization shrinkage, f) lack of adhesion of the material to the tray, g) lack of mechanical retention of materials for which the adhesive is ineffective, h) development of elastic properties in the material before placing the tray in the mouth, i) excess material, j) continuous pressure on the impression material that has already developed elastic properties, k) tray movement during polymerization, l) early tray removal, and m) removal of the impression from the mouth using an incorrect technique[1].

Among the materials available for taking impressions for fixed prosthesis are reversible hydrocolloids, condensation silicones, addition silicones, polysulfides and polyethers. Addition silicones and polyether are the materials of choice due to their characteristics: dimensional accuracy and stability, and greater time margin when making the model, among others. In spite of their advantages, they are often not the most frequently used materials in daily practice in our country, due to their high cost compared to condensation silicones.

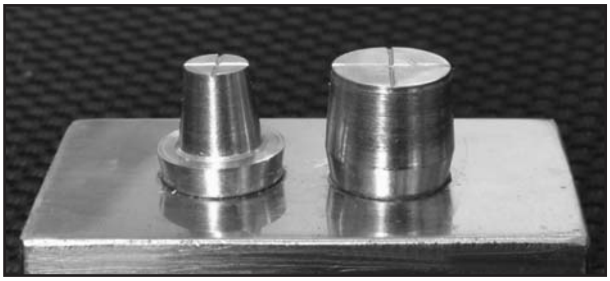

Fig. 1: Lateral view of the metal mold used as a cast for taking impressions.

Fig. 2: Custom tray made of thermoplastic sheet.

The literature describes two different ways of evaluating the dimensional stability of the impression materials: 1) by studying the impression material itself [2,3] and 2) by measuring the casts prepared from an impression [4-8].

Many of the recently published papers do not evaluate the properties of the impression materials themselves, but rather, their effects on impression techniques[9], use of adhesives[10] and decontamination of the impressions[11], among other properties.

Most studies standardize the forms of storage[3,5,8], and therefore do not reproduce the conditions under which the materials are usually stored in during clinical use. In this study, therefore, we did not standardize the storage conditions of the impression during the time up to the preparation of the cast, because we wanted to replicate the conditions that materials are exposed to in their everyday usage.

The aim of this study was to evaluate linear dimensional stability of different impression elastomers over time.

MATERIALS AND METHODS

A metal mold was made (Fig. 1) with its custom trays, which were made of thermoplasic sheets (Sabilex®, 0.125 mm thick) (Fig.2).

The trays were made so that the insertion path was standardized for all impressions, and prepared just before taking the impressions with universal tray adhesive (Zhermack®), following the manufacturer's instructions.

We used three addition silicones – Examix® by GC (AdEx), Aquasil® by Dentsply (AdAq) and Panasil® by Kettenbach (AdPa), and three condensation silicones – Densell® by Dental Medrano (CoDe), Speedex® by Coltene (CoSp) and Lastic® by Kettenbach (CoLa). Table 1 shows the materials, manufacturers and batch numbers.

Three impressions were made from each type of material, using two consistencies – putty and light body – using a one-step impression technique (Fig.3). Standardized photographs were taken at different time times (0, 15, 30, 60, 120 minutes; 24 hours; 7 days and 14 days) with a Sony® digital camera using an ad-hoc device (Figs. 4 and 5) and millimeter ruler as a reference for the measure-

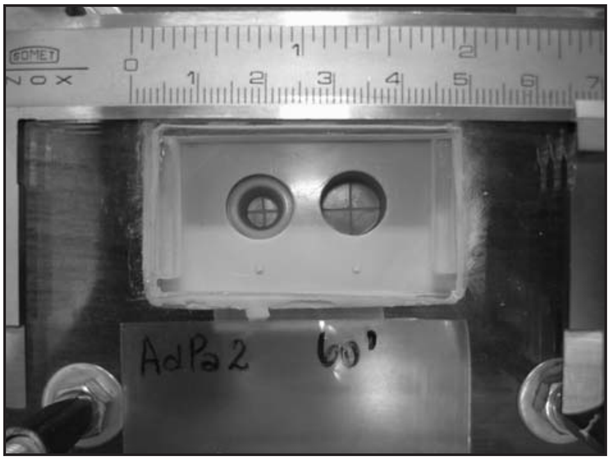

Fig. 3: One-step impression using custom tray, positioned for the photograph.

Table 1: Material used.

	Marca	Fabricante	Consistencia	Lote
Condensación	Densell silicone (CoDe)	Dental Medrano	putty liviana catalizador	GH0469 HH0433 IE0300
	Lastic (CoLa)	Kettenbach	putty liviana catalizador	82021 71421 91681
	Speedex (CoSp)	Coltene	putty liviana catalizador	JC0208 IG0410 184211
Adición	Aquasil (AdAq)	Denstply	putty liviana	90306 90120
	Exaflex-Examix (AdEx)	GC	putty liviana	807021 B0809111/ C0809151
	Panasil (AdPa)	Kettenbach	putty liviana	91631 80091

ments (Fig. 3). The device enabled the position of the camera and the distance to the object to be standardized, and included an add-on so that all impressions would be placed in the same position (Fig.6).

The pictures were analyzed with image processing software (UTHSCSA Image Tool) by measuring the distance between the intersections of grooves previously made at the top of the mold (Fig. 7). The results were put into a spreadsheet and analyzed by Analysis of variance for repeated measurements (Software SPSS 9.0).

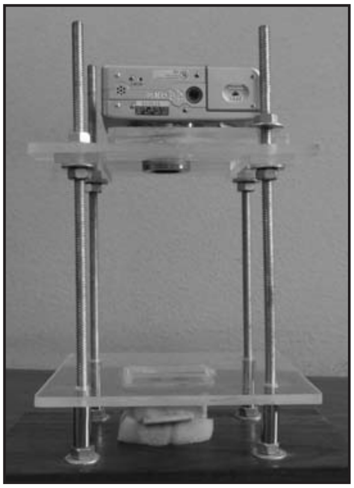

Fig. 4: Lateral view of the ad-hoc device while taking the photograph.

Fig. 5: Top view of impression positioner in the ad-hoc device.

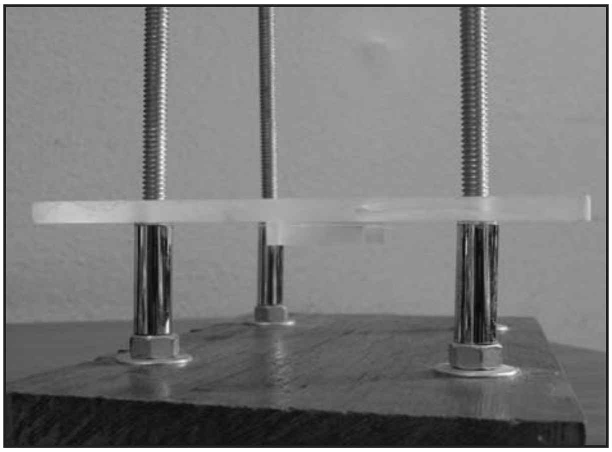

Fig. 6: Lateral view of the impression positioner in the ad-hoc device.

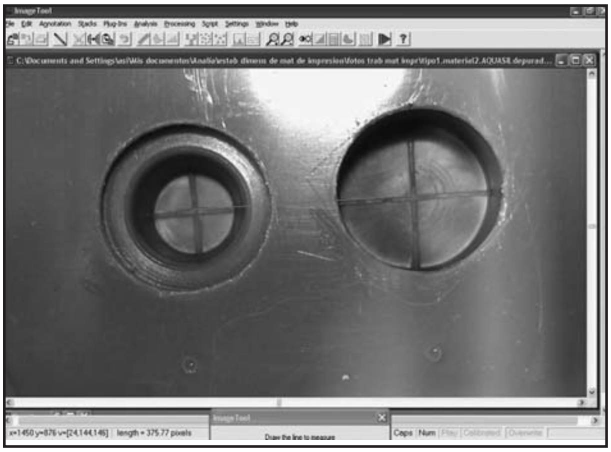

Fig. 7: Measuring with Image Tool image processing software.

RESULTS

Table 2 and Figure 8 show the mean and SD for the measurements at the different times for each material.

Statistical evaluation by ANOVA for repeated measures showed significant differences ($p<0.05$) for type (type of polymerization, Table 3), material (brand, Table 4) and time (Table 5). There were also statistically significant differences for time-material interaction (Table 5).

For the material-material interaction it was found that Examix and Aquasil differ significantly from Panasil, Densell and Lastic, and that Panasil differs significantly from Exaflex and Aquasil.

Densell and Lastic differ significantly from Examix and Aquasil.

Speedex does not differ significantly from any of the materials. Nevertheless, it underwent changes in the reproduction of detail that may have affected the measurements in this study.

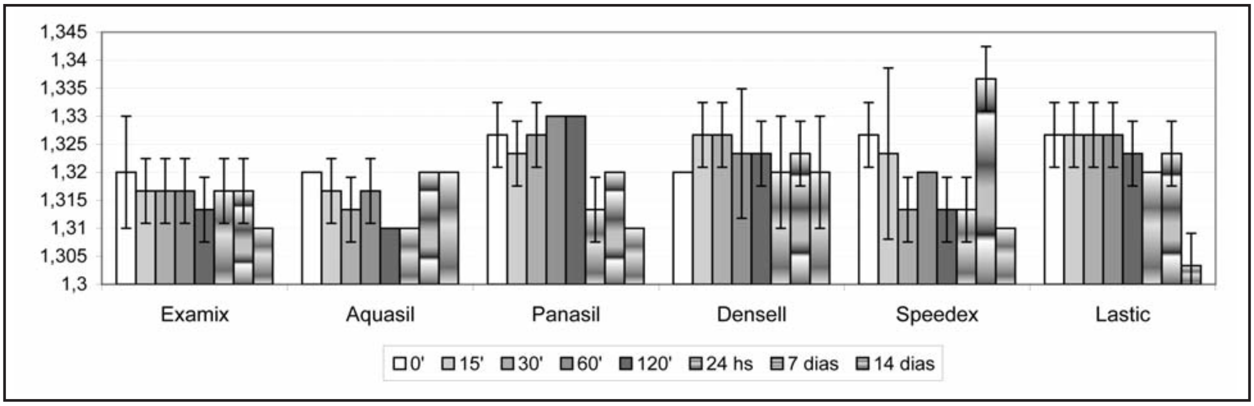

Fig. 8: Distance between the intersections of grooves registered for each material at each evaluation time.

Table 2: Mean and standard deviations obtained for each material at each evaluation time.

		0 min.	15 min.	30 min.	60 min.	120 min.	24 hs.	7 dias	14 dias
Siliconas por adición	Examix (AdEx)	1.3200 (0.0100)	1.3167 (0.0058)	1.3167 (0.0058)	1.3167 (0.0058)	1.3133 (0.0058)	1.3167 (0.0058)	1.3167 (0.0058)	1.3100 (0.0000)
	Aquasil (AdAq)	1.3200 (0.0000)	1.3167 (0.0058)	1.3133 (0.0058)	1.3167 (0.0058)	1.3100 (0.0000)	1.3100 (0.0000)	1.3200 (0.0000)	1.3200 (0.0000)
	Panasil (AdPa)	1.3267 (0.0058)	1.3233 (0.0058)	1.3267 (0.0058)	1.3300 (0.0000)	1.3300 (0.0000)	1.3133 (0.0058)	1.3200 (0.0000)	1.3100 (0.0000)
Siliconas por condensación	Densell (CoDe)	1.3200 (0.0000)	1.3267 (0.0058)	1.3267 (0.0058)	1.3233 (0.0115)	1.3233 (0.0058)	1.3200 (0.0100)	1.3233 (0.0058)	1.3200 (0.0100)
	Speedex (CoSp)	1.3267 (0.0058)	1.3233 (0.0153)	1.3133 (0.0058)	1.3200 (0.0000)	1.3133 (0.0058)	1.3133 (0.0058)	1.3367 (0.0058)	1.3100 (0.0000)
	Lastic (CoLa)	1.3267 (0.0058)	1.3267 (0.0058)	1.3267 (0.0058)	1.3267 (0.0058)	1.3233 (0.0058)	1.3200 (0.0000)	1.3233 (0.0058)	1.3033 (0.0058)

Table 3: Statistical evaluation for the polymerization type variable.

Polimerization type		Mean Difference	Standard Error	Sig	95% Confidence Interval for difference	
					Lower Bound	Upper Bound
1	2	-3.125 E-03	0.001	0.023	-5.74 E-03	-5.14 E-04
2	1	3.125 E-03	0.001	0.023	5.136 E-04	5.736 E-03

Table 4: Statistical evaluation (ANOVA) for the Material variable.

Source	Sum of squares	Degrees of freedom	Mean square	F	Significance
Material	7.408 E-04	4	1.852 E-04	3.959	0.031
Type	0.000	0			
Material* type	0.000	0			
Error	5.146 E-04	11	4.678 E-05		

Table 5: Statistical evaluation for the Time variable.

Effect		Value	F	Hypothesis df	Error df	Significance
Time	Pillai´s Trace	0.977	30.711	7.000	5.000	0.001
	Wilks´Lambda	0.023	30.711	7.000	5.000	0.001
	Hotelling´s Trace	42.995	30.711	7.000	5.000	0.001
	Roy´s largest root	42.995	30.711	7.000	5.000	0.001
Time* Material	Pillai´s Trace	2.453	1.812	28.000	32.000	0.053
	Wilks´Lambda	0.003	2.952	28.000	19.450	0.008
	Hotelling´s Trace	34.380	4.298	28.000	14.000	0.003
	Roy´s largest root	28.660	32.754	7.000	8.000	0.000

DISCUSSION

The literature describes two ways of evaluating the dimensional stability of the impression materials: one by studying the stability of the impression material itself[2,3], and the other by measuring casts made from an impression[4-8]. The latter should consider the setting expansion of the plaster, which would compensate part of the elastomer polymerization contraction.

The dimensional stability of impression silicones evaluated in this study was measured directly on the impression at different time intervals, in order to avoid the variables that are a result of using other materials and could modify it (similar methods and results as in Clancy[2] and Valderhaug[3]).

Clancy[2] analyzed the dimensional stability of 3 materials (an polyvinylsiloxane, polydimethylsiloxane and a polyether) at 8 time intervals up to 4 weeks after the impression was taken, and concluded that the impressions of all materials that are immediately emptied have greater dimensional accuracy, and that after 4 weeks, addition silicone maintained the best surface detail and had very small dimensional changes. Polydimethylsiloxane lost detail within 24 hours, and may have clinically significant distortion at 4 hours after the impression is taken. Our study reached similar conclusions.

We found that the loss of surface detail reproduction in condensation silicones makes measuring difficult (Fig. 9) and this may have affected the measurements taken in this study. This was not a problem in impressions made with addition silicone (Fig. 10).

Valderhaug[3] evaluated a condensation silicone and a polyether, but standardized storage temperature at 21ºC, and considered short storage time intervals, not greater than 24 hours, finding no statistically significant difference between the two groups of materials. Our study, in contrast, evaluated the dimensional stability of the materials over a longer period of time.

The other methodology used involves measuring the casts made from an impression.

The studies by Chen[4], Purk[5], Lapria Faria[6], Marcinak[7] and Federick[8] were all found to have evaluated time intervals not greater than 24 hours. The time limitation may be related to possible dimensional changes in the viscoelastic materials over long periods of time.

Another infrequent variable in the literature was exposure of the impressions to different temperature ranges. This is an important factor to consider when reproducing the environmental conditions that impressions are usually exposed to when they are transferred to the laboratory.

Purk[5] evaluated the effect of temperature on the dimensional accuracy of an addition silicone and a polyether, subjecting the impressions to -10, 24 and

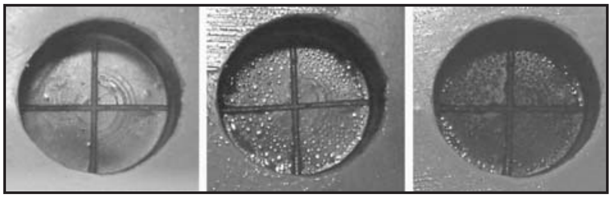

Fig. 9: Comparison of a condensation silicone impression at the time the impression was taken, at 7 days and at 14 days.

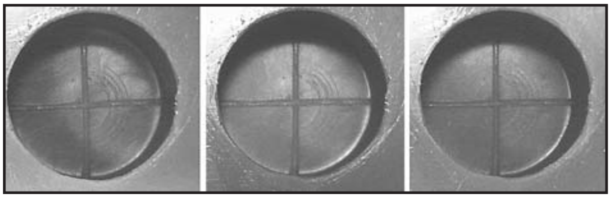

Fig. 10: Comparison of an addition silicone impression at the time the impression was taken, at 7 days and at 14 days.

66ºC, concluding that addition silicones underwent greater dimensional changes than the polyether, and that those changes could have clinical implications. Another conclusion of the study by Purk et al. was that the measurement evaluated on the horizontal plane showed no clinically important variation. However, the influence of the properties of material used to make the cast must be taken into account.

We found little scientific literature evaluating the characteristics and/or properties of impression materials, particularly in recent years. Much of the existing literature studying impression materials focuses on evaluating the influence of the following variables: effect of time, relationship between percentage of filling-dimensional stability, use of some mechanism of adhesion of the material to the trays and type of tray used.

Another observation is that many studies have evaluated the discrepancy between the master cast and the plaster casts in absolute values, expressed as a percentage. Our study only evaluated the differences between impressions, which were recorded at different time intervals, and only attempted to analyze the effect regarding the impressions. The use of casts may add discrepancy factors, because they could add the variation in the cast to the variation in the impression, preventing any more definite conclusions. Moreover, the ad-hoc device used means that the focal distance to the cast might be different from the focal distance to the impression, generating differences in the distance recorded between marks, which could have an influence on the discrepancy between the master cast and the impressions.

CONCLUSION

Under the conditions in this study, we can conclude that impression storage time, type of material and brand used would significantly affect linear dimensional stability of impression elastomers over time.

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CORRESPONDENCE

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