Anatomía Digital

ISSN: 2697-3391
Vol. 7 No. 3, pp. 34 – 52, July – September 2024

www.anatomiadigital.org

Estudio comparativo in vitro de la estabilidad dimensional de diferentes siliconas de adición

Comparative in vitro study of the dimensional stability of different addition silicones

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Scientific and Technological Research Article
Sent: 04/16/2024
Revised: 05/13/2024
Accepted: 06/16/2024
Published: 23/07/2024
DOI:**https://doi.org/10.33262/anatomiadigital.v7i3.3105**

Please quote: Castro García, PA, Mayorga Brito, JP, Carrillo Vaca, DG, & Ortega Leiton, LE (2024). Comparative in vitro study of the dimensional stability of different addition silicones. Digital Anatomy, 7(3), 34-52.https://doi.org/10.33262/anatomiadigital.v7i3.3105

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The journal is published by Editorial Ciencia Digital (a prestigious publisher registered with the Ecuadorian Book Chamber with membership number 663).www.celibro.org.ec

ISSN: 2697-3391
Vol. 7 No. 3, pp. 34 – 52, July – September 2024

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Palabras claves:
contracción, expansión, estabilidad dimensional, polimerización, prótesis, silicona de adición.

Resumen

Introducción: La presente investigación, tuvo por objeto evaluar la estabilidad dimensional de las siliconas de adición de tres diferentes casas comerciales, con el propósito de identificar como la expansión y contracción cumplen su función acorde al tiempo de trabajo dentro de la confección de las prótesis. **Objetivos:** el objetivo de esta investigación fue evaluar la estabilidad dimensional de las siliconas de adición de tres diferentes casas comerciales, posterior a establecer un método de medición de está considerando parámetros como la contracción y la expansión en función del tiempo, logrando así, medir la alteración dimensional de las siliconas a diferentes intervalos de tiempo después del proceso de polimerización, con el objetivo de comparar la estabilidad dimensional de las diferentes siliconas de adición para identificar diferencias significativas en dicha propiedad física. **Metodología:** El tipo de investigación es experimental in vitro, lo que significa que la investigación se realizó en un entorno controlado en el laboratorio, manipulando activamente las variables y observando los resultados. **Resultados:** Para los resultados se consideró la alteración dimensional de las siliconas por adición en intervalos de tiempo con el fin de ver como se desenvuelve la silicona en el proceso de polimerización. **Conclusiones:** El análisis ANOVA detectó diferencias dimensionales significativas entre los diferentes tipos de siliconas, en un periodo corto de 24 horas y un periodo distante de 15 días, mientras que en un periodo medio de 8 días no se encontraron diferencias dimensionales significativas entre estas. Además, se determinó que la silicona President Coltene presenta cambios dimensionales variantes a lo largo del periodo de estudio, este comportamiento es similar al de Ivoclar Vivadent Virtual, aunque esta presentó menor variabilidad, por último, Kerr Extrude es la silicona que menos cambios en el tiempo presentó con respecto a las siliconas antes mencionadas, denotando una consolidación hacia los procesos de contracción respecto al tiempo, que difiere notablemente de las otras siliconas analizadas. **Área de estudio general:** odontología. **Área de estudio específica:** siliconas de adición. **Tipo de estudio:** original, trabajo de investigación.

Keywords:
contraction, expansion,

Abstract

Introduction: The aim of the research was to evaluate the dimensional stability of addition silicones from three different

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dimensional stability, polymerization, prosthesis, silicone addition.

commercial companies, with the purpose of identifying how expansion and contraction fulfill their function according to the working time when making the prostheses. Objectives: The objective of this research was to evaluate the dimensional stability of addition silicones from three different commercial companies, after establishing a measurement method considering parameters such as contraction and expansion as a function of time, thus achieving, measuring the dimensional alteration of the silicones at different time intervals after the polymerization process, with the objective of comparing the dimensional stability of the different addition silicones to identify significant differences in said physical property. Methodology: This experimental research was conducted in a laboratory-controlled environment, actively manipulating the variables, and observing the results. Results: For the results, the dimensional alteration of the silicones by addition at time intervals was considered to observe how the silicone develops in the polymerization process. Conclusions: The ANOVA analysis detected significant dimensional differences between the diverse types of silicones, in an abbreviated period of 24 hours and a distant period of 15 days, while in a medium period of 8 days no significant dimensional differences were found between them. Furthermore, it was determined that the silicone President Coltene presents varying dimensional changes throughout the study period. This behavior is like that of Ivoclar Vivadent Virtual, although it presented less variability. Finally, Kerr Extrude is the silicone that presented the least changes over time with respect to the silicones, denoting a consolidation towards contraction processes with respect to time, which differs notably from the other silicones analyzed.

Introduction

The comparative in vitro study of the dimensional stability of different addition silicones is a relevant topic in the field of dentistry and oral rehabilitation. Impression materials such as addition silicone are used to obtain dental impressions for the subsequent development of study models of the tissues and structures of the oral cavity, from which a rehabilitation treatment plan is achieved.(1).

Therefore, it is necessary to know that a dental impression is a negative replica of the structures and surrounding tissues of the oral cavity, which is obtained by applying an impression material placed on the patient's dental arches.(2-4).

The procedure of taking impressions is routinely performed in dental clinics and can be successfully carried out using the appropriate techniques and materials, many of which today provide satisfactory results in terms of reproducing details. This is why impressions constitute a valuable resource in the diagnosis and treatment of patients, leading to the creation of plaster models that allow the dentist to observe and study the current state of the patient's oral cavity, as well as the creation of prosthetic devices.(5).

In addition, addition silicones are considered an elastomeric type impression material and one of the most suitable for obtaining definitive impressions of oral tissues in the area of prosthodontics.(6, 7). In its operation, this material acts as a polymer, that is, through a chemical activation it will stimulate the function of its bonds and thus, through polymerization, obtain the results we expect.(8)There is a wide variety of this product on the market, which is sold in jars for the heavy portion (putty) and in tubes for the light portion.(9). This material, by generating hydrogen and not alcohol as a by-product, is considered the most dimensionally stable elastomer.(10).

Generally, impressions made with addition silicone obtain better results, they are more exact in addition to the good dimensional stability that this material presents. Dimensional stability is defined as a property of materials, which when subjected to different alterations in the environment such as temperature and humidity, try to preserve their original morphology and dimensions without these being altered.(11).

The objective of this research was to evaluate the dimensional stability of addition silicones from three different commercial companies, after establishing a measurement method that considers parameters such as contraction and expansion as a function of time, thus achieving the measurement of the dimensional alteration of the silicones at different time intervals after the polymerization process, with the aim of comparing the dimensional stability of the different addition silicones to identify significant differences in said physical property.

Methodology

This study was of an experimental in vitro, longitudinal type and with a quantitative, descriptive and quasi-experimental approach. The research was accepted by the Commission of the Dentistry Degree of the National University of Chimborazo.

The study was carried out by manufacturing a stainless steel master model which was used to take impressions, thus having a population group of 36 impressions, which were divided into 12 impressions for each brand, that is, 12 samples with President Coltene, 12

samples Kerr Extrude, and 12 samples with Ivoclar Vivadent Virtual. The sampling was intentional, non-probabilistic and convenience, under the inclusion criteria of impressions with addition elastomers with the already established brands, used correctly based on the manufacturer's instructions, and discarding samples that presented different imperfections in the measurement area.

The study data were obtained through a stereomicroscope, the measurements were analyzed at different time periods after the impression was taken, such as 24 hours, 8 days, and 15 days; allowing statistical analysis to be performed using variance analysis tests (ANOVA) with the SPSS program version 27.

The research was carried out in the U103 laboratory of the Experimental Sciences, Chemistry and Biology Pedagogy course at the National University of Chimborazo. For the study, the use of addition silicones from three commercial brands was established, see figure 1.

Figure 1.A) Coltene-President B) Kerr-Extrude C) Ivoclar Vivadent-Virtual

In addition, a master model was made according to specification number 19 according to the American Dental Association (ADA). The model consists of two structures: a) a block that presents: 3 horizontal lines and 2 vertical lines carved on its upper part, according to the mentioned specification the internal diameter of the master model corresponds to 29.97mm, the equal distance for each side from the central line is 2.5mm, thus forming the horizontal lines; the vertical lines are born by drawing two lines perpendicular to the central line with a distance of 2.48mm from both ends inwards. b) an external ring: that presents a diameter of 38mm, see figure 2.(12 - 16).

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Figure 2. Master model completed with its two structures

Due to the dimensions of the master model, the proportions of the addition silicone were standardized. For the heavy paste, two ¼ teaspoons (activator-catalyst) were used, while for the light paste, the portion of a "click" of the dispensing gun was established, discarding the first fragment.

Once the materials were standardized and the protocol was determined as shown in Figure 3, which will be described below. The obtaining of samples from each study group began. The technique used was the one-step or double mixing technique.(17), first the catalyst is mixed with the heavy paste activator for 15 seconds, immediately the light paste is placed on top of the master model followed by the heavy paste, a glass tile is placed that allows to hold the impression material and ensure the thickness of the samples(13 - 15, 18). It also serves as a support for a 1kg weight that will exert the same pressure on each print, allowing for detailed reproduction of the lines drawn on the master model.(13, 15, 16)The working time recommended by the manufacturer was doubled in each case to compensate for the temperature of the oral cavity.(14, 19, 20).

Nitrile gloves were used at all times, avoiding the use of latex gloves, thus avoiding the risk of possible alterations in the polymerization of the impression material.(14, 18). At the end of obtaining each sample, the master model was cleaned using alcohol swabs, in order to eliminate residues that may appear in the grooves of the drawn lines.(13).

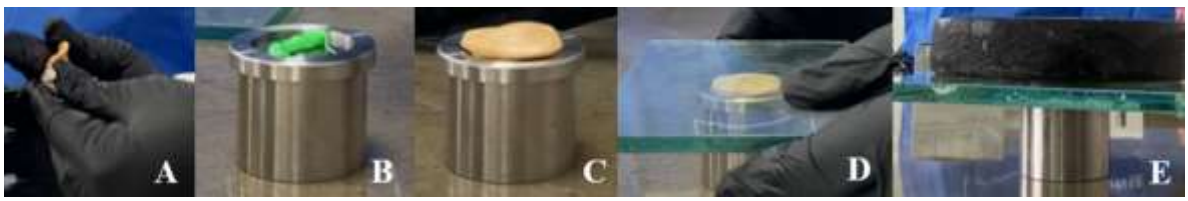

Figure 3.*Printing protocol. A) Mixing the heavy paste. B) Application of the light paste. C) Application of heavy paste. D) Placing the tile. E) Placing the weight.*

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A group of 12 samples was prepared for each addition silicone, for a total of 36 samples, which is shown in Figure 4. To establish that the samples were acceptable for the study, they had to reproduce the surface of the master model clearly. On the other hand, the samples that presented irregularities, detachments, roughness or any other alteration in the reference points were established as unacceptable.(13, 18).

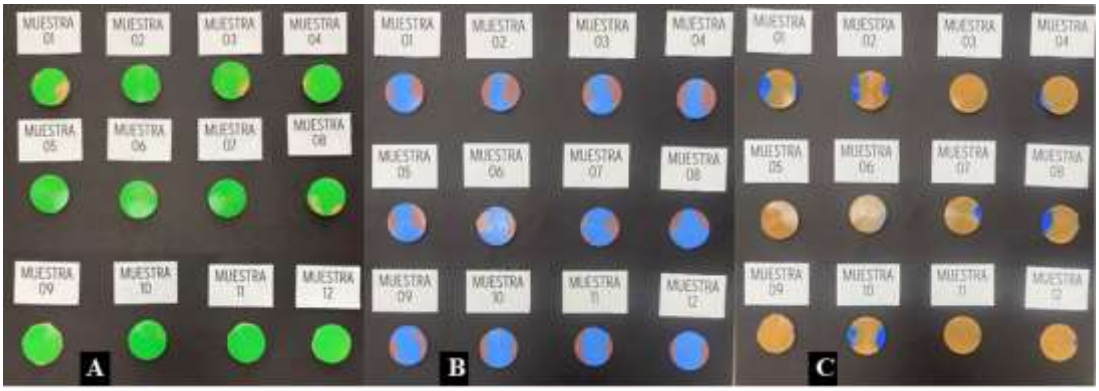

Figure 4.*Samples. A) Coltene-President B) Kerr-Extrude C) Ivoclar Vivadent-Virtual*

For the study, the Stemi 508 stereomicroscope was used together with the Axiocam 208 color camera, from the Zeiss brand, which can be seen in Figure 5. The equipment was calibrated with a magnification of 1.25x and a precision of 1000um.(12, 20).

Figure 5.*Stemi 508 stereomicroscope and Axiocam 208 color camera, from Zeiss*

To perform the microscopic measurement of the changes in time presented by the addition silicones, six points were determined (A, B, C, D, E, F) with the union of two points forming four segments (AB, BC, DE, EF). Each study group was analyzed in three different time periods: 24 hours, 8 days and 15 days (figure 6 - 8). The measurements of the samples were obtained from the Labscope-Zeiss application. The entire microscopy procedure was performed by a single operator, in order to minimize optical discrepancies at the time of sample measurement.(20).

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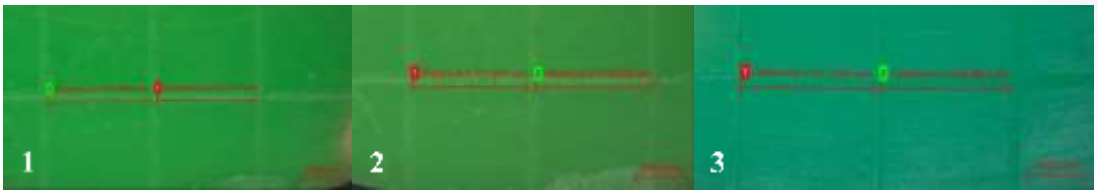

Figure 6.*President Coltene (1. 24 hours, 2. 8 days, 3. 15 days)*

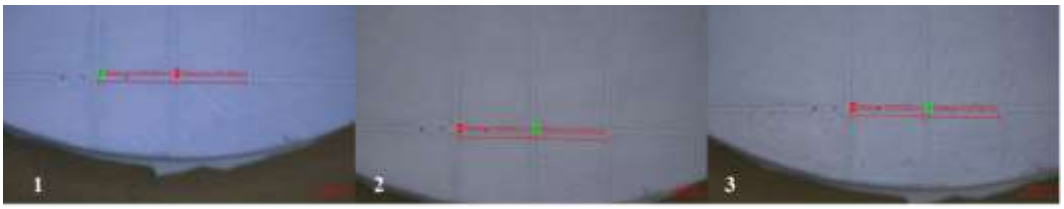

Figure 7.*Kerr Extrude (1. 24 hours, 2. 8 days, 3. 15 days)*

Figure 8.*IvoclarVivadentVirtual (1. 24 hours, 2. 8 days, 3. 15 days)*

Once the study is completed and the measurements of each group of samples are obtained, a checklist is made grouping the results according to the segments in the different time periods in which the analysis was carried out for each study group.

Results

The President-Coltene silicone group showed a strong mean contraction in the short term (68.1 μM), which became more pronounced in the medium term (18.68 μM) and in the long term it experienced a slight expansion (-5.75 μM). The substantial reduction in the standard deviation (from 23.65 to 13.39 μM) reinforces that the behavior becomes homogenous after the initial state (Table 1).

Table 1.*Difference in dimensional alteration in relation to time (President Coltene)*

Dimensional Difference (24 h)		Dimensional Difference (8 d)		Dimensional Difference (15 d)	
Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
68.1	23.65	18.68	20.25	-5.75	13.39
* Negative values denote material expansion (uM)					
**Positive values indicate material shrinkage (uM)					

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Kerr-Extrude presented a relatively high average shrinkage in the short term (43.56 μM), which decreased in the medium term (24.66 μM) and in the long term (24.8 μM). The standard deviation increased steadily (from 9.14 to 28.2 μM), revealing an increasing variability in the dimensional behavior with polymerization (Table 2).

Table 2. Difference in dimensional alteration in relation to time (Kerr-Extrude)

Dimensional Difference (24 h)		Dimensional Difference (8 d)		Dimensional Difference (15 d)	
Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
43.56	9.14	24.66	25.51	24.8	28.2
* Negative values denote material expansion (uM)					
**Positive values indicate material shrinkage (uM)					

IvoclarVivadent-Virtual presented a relatively high average contraction in the short term (31.07 μM), which decreased in the medium term (12.46 μM) and in the long term experienced a slight expansion (-1.92 μM). The standard deviation increased slightly during the process (from 5.81 to 8.04 μM), revealing a certain increase in dimensional variability (Table 3).

Table 3. Difference in dimensional alteration in relation to time (Ivoclar Vivadent Virtual)

Dimensional Difference (24 h)		Dimensional Difference (8 d)		Dimensional Difference (15 d)	
Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
31.07	5.81	12.46	9.98	-1.92	8.04
* Negative values denote material expansion (uM)					
**Positive values indicate material shrinkage (uM)					

The analysis of the AB segment shows a greater expansion trend at all times except for President-Coltene in the short term, differing from the general behavior of the samples (Figure 9).

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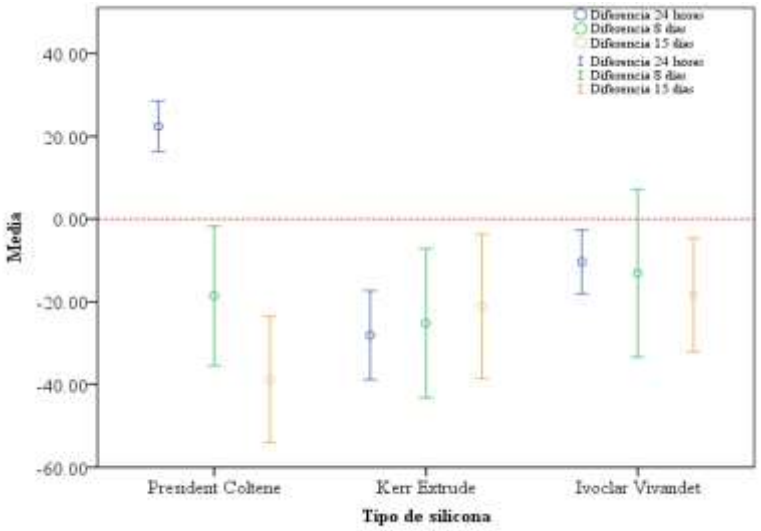

Figure 9. Comparison of differences by type of silicone uM (AB)

In the BC segment, a contraction was evident in all samples, more prominent in the short term, the Kerr-Extrude group showed greater variability in the medium term (Figure 10).

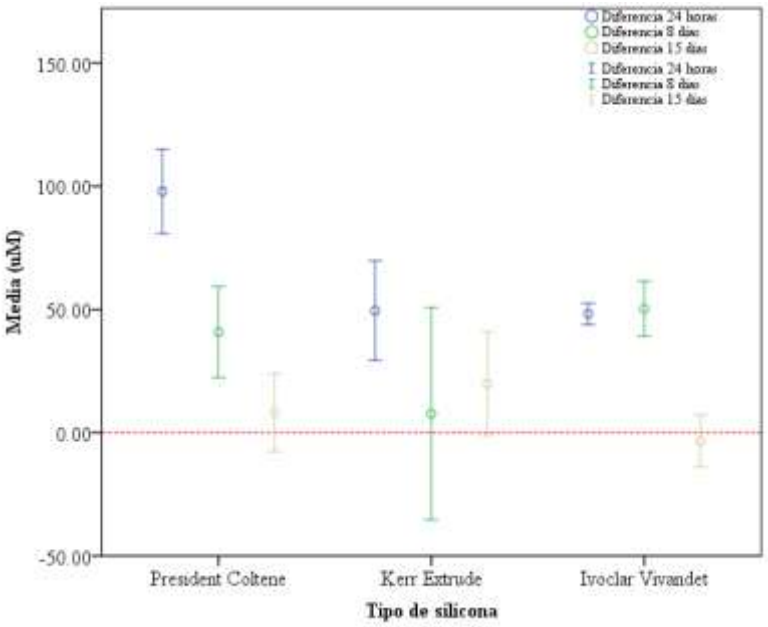

Figure 10. Comparison of differences by uM silicone type (BC)

The DE segment shows a constant contraction in all samples, the Kerr-Extrude group shows greater variability in the medium and long term (Figure 11).

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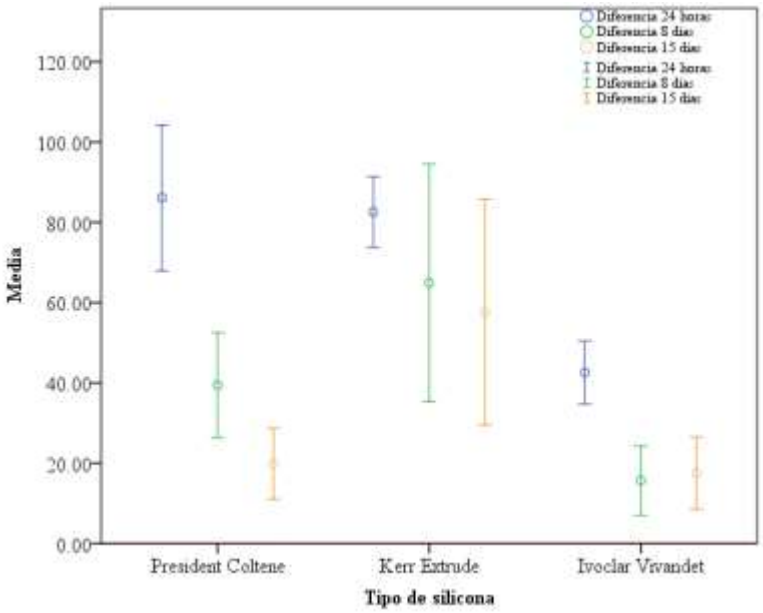

Figure 11. Comparison of differences by type of silicone uM (DE)

The EF segment demonstrated a different behavior when finding that the President-Coltene and Ivoclar groupsVivadent-Virtual expanded especially in the medium and long term (figure 12).

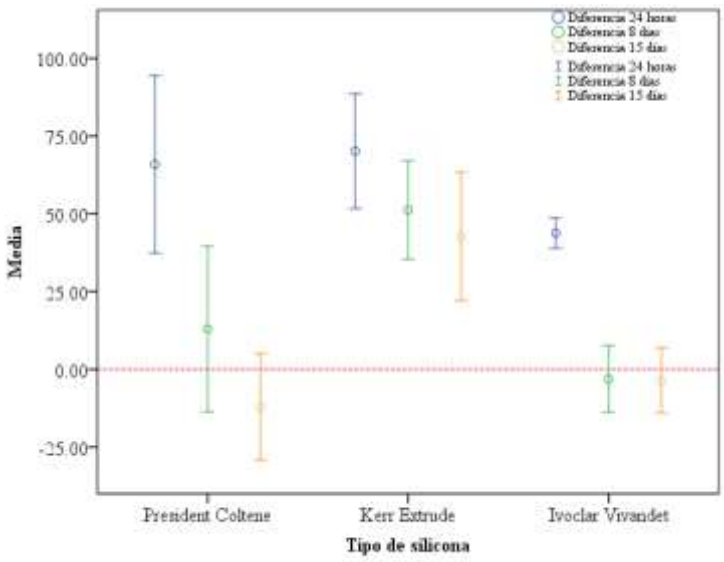

Figure 12. Comparison of differences by type of uM silicone (EF)

Comparing the average differences by study group, it was found that the President-Coltene silicone group was very variable in its dimensional changes, indicating that it showed contraction values in the medium term and expanded in the long term, similar to the Ivoclar group.Vivadent-Virtual, although with less variability, the Kerr-Extrude group

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turns out to be the one with the least changes in the study period, demonstrating a constant margin of contraction (figure 13).

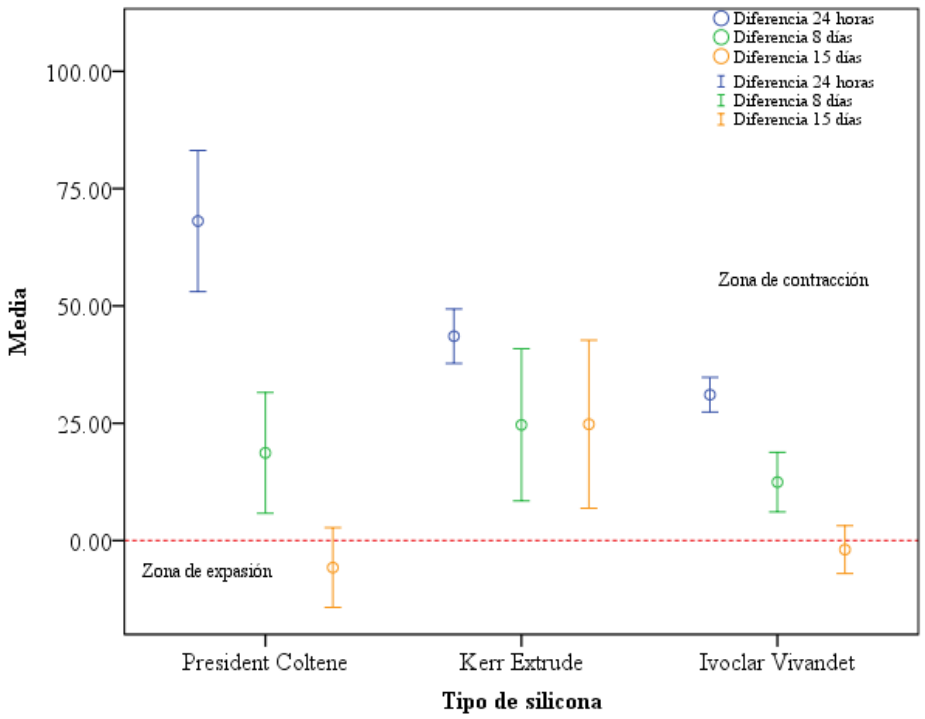

Figure 13. Comparison of average differences of all segments by silicone type

To determine significant differences between sample groups, the following hypothesis is proposed:

H0= There are no significant differences between the types of silicone and their dimensional alteration at 24 hours, 8 days and 15 days.

IC=95%

Error=5%

Test decision: If p<0.05 reject H0

Through an ANOVA analysis it is determined that at 24 hours the p value (sig.) is less than 0.05 rejecting the null hypothesis, after 8 days the p value is greater than 0.05 so the null hypothesis is not rejected and after 15 days the p value is again less than 0.05 rejecting the null hypothesis. Through the ANOVA analysis significant differences are detected between the study groups in the short and long term, but not in the medium term (Table 4).

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Table 4.ANOVA test

		Sum of squares	gl	Root mean square	F	Next.
Average dimensional difference 24 hours	Between groups	8514.48	2	4257.24	18.883	0.000
	Within groups	7439.782	33	225,448		
	Total	15954.262	35			
Average dimensional difference 8 days	Between groups	893.855	2	446.927	1.156	0.327
	Within groups	12761.587	33	386,715		
	Total	13655.442	35			
Average dimensional difference 15 days	Between groups	6645.581	2	3322.79	9.593	0.001
	Within groups	11430.795	33	346.388		
	Total	18076.376	35			

Discussion

Different methodologies are used to measure the study of dimensional stability, with the same objective: to demonstrate the changes that may occur with respect to said property. Microscopy equipment is another measurement tool with a high percentage of accuracy, since it allows us to perform an analysis of microscopic objects that are difficult to analyze with the human eye, enhancing the precision in the measurements that the different samples may present, as referenced by different authors in their studies.(10, 12, 13, 20–24).

After an analysis of the different measurement methods used in the different studies analyzed above, in order to avoid errors in the measurement of the samples, the criterion of Farzin et al. was shared.(20)in the use of reliable measuring equipment, such as the stereomicroscope, which, unlike other microscopes, allows us to have a three-dimensional view of the samples to be analyzed. The Stemi 508 stereomicroscope together with the Axiocam 208 color camera, from Zeiss, through the Labscope-Zeiss application allows us to measure microscopic lengths from established points.

Hinostroza(25), in his study he was able to show that the President Coltene silicone, after 24 hours, presents a considerable contraction with respect to its base model. The results of this study reaffirm the author's position, because this silicone during the 24-hour period presented a strong contraction with respect to the reference measurements of the master model. In a study carried out by Rodríguez & Bartlett(15), showed that after 15 days, the group of silicones studied showed a general tendency to shrink with respect to the

measurement of the study block, with President Coltene silicone being part of this group. The authors' assertion is shared, since it was evident that during the 15 days the silicone was subject to the phenomenon of shrinkage, presenting obvious variations in its dimensional changes.

Rodriguez & Bartlett(15)In their study of the dimensional variations of various printing materials, they evaluated the behavior of the Kerr Extrude addition silicone over different time periods. The analysis within the first 24 hours indicates that this silicone presents a contraction with respect to the measurement of its study block, a phenomenon that continues to be evident in the analysis of the samples after 15 days. The contraction of this printing material remains without marked variations in its dimensional changes, as in the Kerr Extrude samples analyzed in this study, where after 24 hours they presented contraction, maintaining a constant margin of contraction after 15 days.

Regarding the behavior of the Ivoclar Vivadent Virtual addition silicone, during its analysis it was observed that after 24 hours a high contraction is evident, which decreases after 8 days, and after 15 days it presents a slight expansion with respect to the reference measurements of the master model. This postulation differs from the study carried out by Al-Zarea & Sughaireen.(24), where they show that the addition silicone Ivoclar Vivadent Virtual does not go through a contraction stage, on the contrary, it presents minimum expansion values at 8 days that remain constant at 15 days, detailing minimal dimensional changes.

Based on the results obtained in the present study, with respect to the initial dimensional changes, it can be determined that after 24 hours significant differences are evident between the silicones studied, while in the period of 8 days the silicones present homogeneity between their dimensional values, finally after 15 days the dimensions of the silicones again present differences.

Conclusions

- Once the bibliographic analysis was carried out and taking into account the recommendations, the microscopy equipment was established for the study, using the Stemi 508 stereomicroscope together with the Axiocam 208 color camera, from the Zeiss brand, as the measuring equipment for dimensional stability.
- Through the Labscope-Zeiss application, it was possible to analyze the dimensional variations presented by the different addition silicones studied, from 36 samples that were analyzed in different time periods established in 24 hours, 8 and 15 days, taking into account the polymerization reaction of the material.
- After analyzing the statistical results of this research, it was determined that President Coltene silicone presents variable dimensional changes throughout the study period, this behavior is similar to that of IvoclarVivadentVirtual, although

it presented less variability; finally, Kerr Extrude is the silicone that presented the least changes over time with respect to the aforementioned silicones, denoting a consolidation towards the contraction processes with respect to time, which differs significantly from the other silicones analyzed.

Conflicts of interest:

The authors declare that there is no conflict of interest in relation to the submitted article.

Authors' contribution statement:

Each of the authors contributed to the writing, review and editing of the article. Principal authors and those who developed the respective study PACG and JPMB, collaboration and verification of results DGCV and LEOL. All authors have read and accepted the written version of the manuscript.

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Anatomía Digital

ISSN: 2697-3391
Vol. 7 No. 3, pp. 34 – 52, July – September 2024

www.anatomiadigital.org