THE DIMENSIONAL STABILITY OF FOUR ELASTOMERIC IMPRESSION MATERIALS

DIMENZIONALNA STABILNOST ČETIRI ELASTOMERNA OTISNA MATERIJALA

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ABSTRACT

Objective: The aim of this study was to determine and compare the linear dimensional change of four frequently used elastomeric impression materials: two vinyl polysiloxane, one polyether, and one condensation silicone.

Material and Methods: Test of linear dimensional change was conducted according to the standardized method that has been described in ISO 4823.A stainless steel test block with engraved reference lines was used for impressions making. A total of 12 specimens (three specimens of each material) were made. The linear dimensional change of specimens was evaluated under the microscope after 24h have been elapsed since their preparation. The distance between the cross-lines, along the horizontal 75μm-wideline, was measured on the test block and on each sample three times. The percentage of linear dimensional change was calculated for each sample. The data was subjected to analysis of variance (ANOVA) and Scheffe's post hoc test.

Results: The lowest value of dimensional change was determined in addition silicone Virtual (0.03 ± 0.11%), followed by polyether Impregum (0.10 ± 0.07%), addition silicone Elite H-D+ (0.18 ± 0.03%), and condensation silicone Oranwash L (0.36 ± 0.39%).Statistical analysis showed that the detected differences between the impression materials are not significant ($p>0.05$).

Conclusion: Addition silicones and polyether displayed superior dimensional stability in relation to condensation silicone also showing a low change in dimension, but was less stable compared to the other tested elastomers. The dimensional stability of all examined impression materials was in compliance with ISO 4823.

Key words: elastomeric impression material, dimensional stability, linear dimensional change, vinyl polysiloxane, polyether, condensation silicone

SAŽETAK

Cilj: Cilj ove studije bio je da odredi i usporedi linearnu dimenzionalnu promjenu četiri često korištena elastomerna otisna materijala: dva vinil polisiloksana, jednog polietera i jednog kondenzacionog silikona.

Materijal i metode: Test linearne dimenzionalne promjene izveden je u saglasnosti sa standardiziranom metodom koja je opisana u ISO 4823. Za izradu otisaka korišten je testni blok od nehrđajućeg čelika sa referentnim linijama. Napravljeno je ukupno 12 uzoraka (tri uzorka od svakog materijala). Linearna dimenzionalna promjena evaluirana je pod mikroskopom nakon 24 sata od pripreme uzoraka. Rastojanje između poprečnih linija, duž horizontalne linije širine 75 μm, izmjereno je na ispitnom bloku i na svakom uzorku tri puta. Za svaki uzorak izračunat je procenat linearne dimenzionalne promjene. Podaci su podvrgnuti analizi varijance (ANOVA) i Scheffe post hoc testu.

Rezultati: Najniža vrijednost dimenzionalne promjene utvrđena je kod adicionog silikona Virtual (0,03 ± 0,11%), a slijede ga polieter Impregum (0,10 ± 0,07%), adicioni silicon Elite H-D+ (0,18 ± 0,03%) i kondenzacioni silikon Oranwash L (0,36 ± 0,39%).

Statistička analiza je pokazala da otkrivene razlike između elastomernih otisnih materijala nisu značajne ($p>0,05$).

Zaključak: Adicioni silikoni i polieter su pokazali superiorniju stabilnost dimenzija u odnosu na kondenzacioni silikon, koji je također imao malu promjenu u dimenziji ali je bio manje stabilan u odnosu na druge testirane elastomere. Dimenzionalna stabilnost svih ispitivanih otisnih materijala bila je u skladu sa ISO 4823.

Ključne riječi: elastomerni otisni materijali, dimenzionalna stabilnost, linearna dimenzionalna promjena, vinil polisiloksan, polieter, kondenzacioni silikon

Introduction

The first impression technique was presented by Philip Phaffin in 1755. Since that time, when the impressions were made with softened wax, until today, the properties of impression materials have been significantly enhanced [1]. The contemporary prosthodontics commonly use the elastic impression materials (hydrocolloids and elastomers) [2]. Elastomeric impression materials are superior than hydrocolloids because of their accuracy and reliability [2-6]. The rubber impression materials are used worldwide, and consider to be the gold standard for impression materials in the fixed prosthodontics [7]. Furthermore, they are the materials of choice in the removable prosthodontics, [8] and in the implant dentistry [9]. Chemically, the four kinds of elastomers are used as the impression materials: polysulfide, polyether, condensation and addition silicones [10]. Although these are the best materials on the market, each possesses specific advantages and disadvantages [11]. Knowledge of the strengths and weaknesses, as well the physical and biological properties of different materials, can provide their successful use [12]. One of the crucial physical properties of the impression materials is the dimensional stability because it affects the quality of prosthetic restoration [13,14]. The error made at making impression stage cannot be fixed in the further process. Moreover, it becomes a source of new inaccuracies [7]. Thus, the accurate impression is the key to restorative success [15]. Accuracy of the impression material depends on dimensional stability [16]. Main causes of the dimensional changes of impression materials are thermal contraction, polymerization shrinkage, and contraction due to loss of volatile by-products [17]. Furthermore, several clinical parameters, such as periodontal status, oral hygiene, location of the preparation finish lines [18,19], tooth mobility [20], and mandibular deformation during the opening [21], can affect the accuracy of an impression. The impression technique, impression tray and properties of the impression material as well contribute to the accuracy of impressions,[9,18,19,22,23] including factors related to laboratory processes, should also be considered when producing prosthetic restorations [24].

Several studies investigated the dimensional changes of impression materials, and the results are not consistent. Literature has not yet achieved consensus about the most accurate elastomeric impression material. Considering the great varieties of impression materials, a testing of their dimensional accuracy can be helpful for professionals who wish to select the best material and achieve the most successfully clinical results [8].

Therefore, the aim of this study was to determine and compare the linear dimensional change of four frequently used elastomeric impression materials: two vinyl polysiloxane, one polyether, and one condensation silicone.

Material and Methods

In the present in-vitro study following elastomeric impression materials were tested: 2 addition silicones (Virtual; type 2, IvoclarVivadent AG, Schaan, Liechtenstein, and Elite H-D+; type 3, Zhermack, Badia Polesine (RO), Italy), polyether (Impregum F; type 2, 3M Espe, St. Paul, Minnesota), and condensation silicone (Oranwash L; type 3, Zhermack, Badia Polesine (RO), Italy).

The test of linear dimensional change was performed in accordance with ISO 4823.[25] The recommended stainless steel test block with five reference V-shaped grooves on its top surface, and the acrylic ring molds were used to produce the sample. The test block was cleaned (with ethanol and ultrasonically), air-dried, and together with the ring mold heated in an incubator (15 minutes at 35°C±1°C). Impression materials were prepared according to the manufacturer's recommendations. The ring mold was connected to the test block, and the mixed material was injected into existing cavity, covered by a polyethylene foil, pressed with a glass plate, and placed in the C-clamp. The specimen was polymerized in water bath at 35°C±1°C, and removed one minute after the manufacturer's recommended setting time. The specimen with the ring mold was then separated from the test block, rinsed under a stream of distilled water, and dried with compressed air. A total of 12 specimens (three specimens of each material) was made, covered with talc from the bottom side, placed on a glass plate, and left in the air in a lab during the next 24 hours. After the mentioned period, the specimens were evaluated under the microscope with measurement accuracy of 0.1 µm (ZKM 01-250C, 2-coordinate measuring microscope, Carl Zeiss, Jena, Freiberg, Germany). The distance between the cross lines, along the horizontal 75µm-wideline, was measured on the test block and on each sample three times. For each sample, the percentage of linear dimensional change was calculated (ΔL) by the formula $\Delta L=((L_1-L_2)/L_1)\times 100$, where L_1 represents the mean of three readings of the test block, and L_2 represents the average of three measurements of the specimen.

The data was subjected to One-Way analysis of variance (ANOVA) and Scheffe's post hoc test. Each test was conducted at the .05 alpha level.

Results

Mean and standard deviation values of dimensional changes in the tested elastomeric impression materials are presented in **Table 1**. The lowest mean of linear dimensional change was observed in addition silicone Virtual (0.03 ± 0.11%), followed by polyether Impregum (0.10 ± 0.07%), and addition silicone Elite H-D+(0.18 ± 0.03%). In comparison with other tested impression materials, the largest mean and standard deviations of dimensional change were found in condensation silicone Oranwash L (0.36 ± 0.39%).

The statistical significance of determined differences in dimensional stability between the four impression materials was tested with One-Way Analysis of Variance (ANOVA), and the results from the test are shown in **Table 2**. It is obvious that the F-value of 1.44 with degree of freedom of 3 resulted in a statistically insignificant p- value (p=0.30).

Furthermore, Scheffe's post hoc test was performed for the comparison of each pair of impression materials **(Table 3).** Between addition silicone Virtual and condensation silicone Oranwash L the lowest p-value to Scheffe's post hoc test was achieved (p=0.34). However, the individual comparisons of dimensional changes resulted in statistically insignificant value of p-parameter (p>0.05) for all possible combinations of pairs of the tested impression materials.

		Elastomeric impression materials			
		Virtual	Elite H-D+	Oranwash L	Impregum F
ΔL	x	0.03%	0.18%	0.36%	0.10%
	SD	0.11	0.03	0.39	0.07
	N	3	3	3	3

Table 1.
Mean and standard deviations of linear dimensional change (ΔL) for evaluated impression materials

Analysis of Variance (ANOVA)	Sum of Squares	Degree of freedom	F- value	p- value
Between groups	0.18	3.00	1.44	0.30
Within groups	0.34	8.00		
Total	0.52	11.00		

Table 2.
The comparison of the linear dimensional change (ΔL) for four impression materials using ANOVA

Scheffe
Dependent variable: The percentage of linear dimensional change

	(J) Material	Mean Difference (I-J)	p
Virtual	Elite H-D+	-0.2	0.84
	Oranwash L	-0.3	0.34
	Impregum F	-0.1	0.98
Elite H-D+	Virtual	0.2	0.84
	Oranwash L	-0.2	0.78
	Impregum F	0.1	0.97
Oranwash L	Virtual	0.3	0.34
	Elite H-D+	0.2	0.78
	Impregum F	0.3	0.54
Impregum F	Virtual	0.1	0.98
	Elite H-D+	-0.1	0.97
	Oranwash L	-0.3	0.54

Table3.
The comparison of dimensional stability between four elastomeric impression materials by using Scheffe's post hoc test (Comparison of individual pairs of groups)

Discussion

The methodology for evaluating the dimensional stability of elastomeric impression materials is not uniform in the literature. The present study applied the test method that has been recommended by ISO 4823 [25]. This approach provides the standardized conditions to test and compare the materials, although some have criticized the testing conditions that vary from those met in clinical practice.

Therefore, the master models used in some previous studies were designed as an edentulous ridge, half or full dental arch, the teeth prepared for a crown, etc. Furthermore, Quicket al.[26] have presented 3D testing for dimensional accuracy of impression materials. However, the ISO 4823 approved test method was also been used before, and its benefit is widely accepted in the dentistry. Moreover, it could be considered that the studies of dental materials have not been serious if not based on the relevant standards [12].

In this study, the dimensional change of each sample was lower than 1.5%, and therefore, all evaluated materials satisfy the requirement of ISO 4823, regarding of dimensional stability. The tested materials showed a certain degree of the contraction, in line with the manufacturer's specifications. The established differences between the various materials were not statistically significant, although there was a tendency of the greater stability of addition silicone Virtual, and the tendency for the least stability of condensation silicone Oranwash L.McCabe and Storer [17] inform that addition silicones have less polymerization shrinkage than condensation silicones.

During the polymerization of the condensation silicones a volatile byproduct is released. Therefore, their mode of polymerization leads to the dimensional instability [27]. Evaporation of ethanol continues even up to seven days after the setting of condensation silicones was completed [28]. Anyhow, Baldissara et al.[29] have found the greatest change in condensation silicone Oranwash L in the first 24 hours (0.68%), while the stability was insignificantly altered during the following seven-day period (0,71%).

Šimunović-Šoškić et al.[30], have shown similar contractions of condensation silicones (Xantopren; Bayer, Germany and RTV; Bosnalijek, Sarajevo, Bosnia and Herzegovina) after 24 hours (0.665% and 0.664%), but also recommended that the impressions of these materials should be poured as soon as possible because of evident loss of stability over time. Condensation silicones were less dimensionally stable compared to the addition silicones and polyethers in some previous studies [31, 32]. However, it is difficult to correlate the results because these studies used different master models and/or brands of impression materials that may influence the disagreements between the results. In addition, there is also a possibility that the established differences between condensation silicone and the other materials in the present study could be of the statistical significance if the testing was performed on a larger sample. Previously mentioned should be considered as a limitation of this study.

The vinyl polysiloxanes show a superior dimensional stability, primarily because they do not release any byproducts during the polymerization [10, 33, 34]. High dimensional stability of the addition silicones [35, 36] allowed to pour the impressions and to fabricate accurate models even seven days after [37]. Thus, if delayed pouring of impressions is anticipated, the addition silicones are better choice than the other elastomers [38]. According to the results of this study, the addition silicones did not differ importantly among themselves, with regard to dimensional stability. Vitti et al. [39] have obtained similar results. Katyayan et al. [40] have compared the linear dimensional changes of two hydrophilic vinyl polysiloxane (type 2) under dry, moist, and wet conditions. Statistical analyses revealed no significant difference between materials for the moist and wet conditions, and a significant difference between materials under the dry condition ($p=0.043$), indicating that only in a dry atmosphere, the mono phase consistency shows the lesser dimensional change than the regular body consistency. However, in their study, the dimensional changes of vinyl polysiloxanes were also negligible, confirming the exceptional accuracy of these materials.

In the literature, most of the conflicting attitudes have been related to the mutual comparison of dimensional stability of addition silicones and polyethers. So, some consider that the addition silicones are superior in relation to polyether [6, 32, 41], but the contrary results have also been presented [42-44]. In this study, the significant differences have not been found between these two groups of materials. Fariaet al. [31] have obtained similar results, but with a different methodological approach. Master model that simulated a partially edentulous mandibular hemi-arch segment with teeth prepared to receive full crowns was used. Polyether (Impregum) and addition silicone (Aquasil LV) were tested, and stone casts were fabricated from the impressions. Photographs of the master model or stone casts and a caliper, set at 1 mm, were taken using a digital camera. The software Image Tool was used to measure the distance between the teeth. Statistical analysis showed no significant difference between the polyether and addition silicone impression materials (single-phase mix technique). When a double-mix technique was used with the addition silicone, the polyether was statistically more accurate. In the literature, the opinions are also divided with regards to the long-term dimensional stability of polyethers. Luebke et al.[45] have found that this material does not change considerably, even after seven days. To the contrary, other studies confirmed that the accuracy of the polyether change importantly depending on the time the impression was made and the humidity of the environment [46, 47]. Anyway, both polyethers and addition silicones, have become very popular and are the most-used impression materials today [48].

Conclusion:

Addition silicones and polyether displayed superior qualities in terms of dimensional stability in relation to condensation silicone, which also showed a low change in dimension, but was less stable compared to the other tested elastomers. The dimensional stability of all examined impression materials was in compliance with ISO 4823.

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