



# Laboratory investigation of Accuracy of Impression Materials for Border Molding

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**Introduction:** Border molding of the edge of the individual impression tray is an important stage of prosthetic treatment of edentulous jaws, which often depends on the final result of the treatment. Classical thermoplastic impression materials for border molding have positive qualities that make them preferable by clinicians for their hardness, unlimited manipulation time and high impression sharpness. Modern silicone impression materials for border molding have long manipulating time and appropriate viscosity to allow dentists to perform functional tests.

**Aim:** To determine the accuracy of different impression materials for border molding of individual impression trays.

**Materials and methods:** Four impression materials for border molding were laboratory tested: Kerr impression compound green sticks and thermoplastic GC Iso functional sticks, additive type silicone Detaseal function and condensation type silicone sta-seal f. A modified individual impression tray designed by authors was used, allowing for laboratory load and stability. Ten impressions were taken and their formed edges were measured at 10 points three times - immediately after hardening/elasification, and 24 hours and 48 hours after hardening/elasification.

**Results:** The results were analysed using ANOVA repetition analysis, where a statistically insignificant difference in the accuracy of three of the impression materials for border molding was established, except the C-type of silicone.

**Conclusions:** Good manipulative qualities and measured accuracy in laboratory tests define these materials as very good for border molding procedures.

## Key words:

border molding, impression material, complete dentures

## INTRODUCTION

Border molding of individual impression trays is an important stage in the prosthetic treatment plan for edentulous jaws, which determines the stability of the prosthesis during rest and function. Applying the border molding procedures reduces the deformation of the alveolar crest and the border soft tissues, resulting in increased retention

and stability.<sup>1</sup> Mucostatic methods lead to an inadequate impression and in many cases cause failure.<sup>2-4</sup> In a comparative study, it was found that the force required to detach a denture made with functional and non-functional impression technique was 53% greater.<sup>5</sup> In the case of shortened treatment without border molding, there was a statistically significant difference in the number of visits and the number of decubitus ulcers after the insertion of the complete dentures.<sup>6</sup>

Of significance for a correct impression of the gingivobuccal sulcus is not only its depth but also its width, a factor which is often underestimated.<sup>7,8</sup> The most commonly applied border moulding tests are the Herbst tests for border molding.<sup>9</sup> The determination of the borders of the prosthesis is influenced by anatomical structures - muscles, muscular and soft-tissue gripping.<sup>5,10</sup> In the distal region, the transverse line is located in the paratuberal space to facies infratemporalis maxillae. An asymmetry between the left and right halves of upper and lower jaws has been established.<sup>11,12</sup>

The impression accuracy depends not only on what type of technique we use, but also on the type of the impression material used for the purpose. The choice of material depends on the anatomical features of the prosthetic field.<sup>9,13</sup> Solid, thermoplastic and silicone impression materials can be used for border molding.<sup>14,15</sup> Thermoplastic materials include impression compound, waxes and wax masses with a working temperature range. They should be used carefully on retentive arches.<sup>16,17</sup>

Additive type silicones show overall stability up to 7 days after impression taking, but despite the proper storage of many authors recommended up to 48 hours.<sup>18,19</sup> Condensation type silicones have polymerization reaction associated with side product release, which decrease their volume.<sup>20</sup> Furthermore volume change is possible and deviation.<sup>21</sup> The linear change is not the same in the three dimensions of the impression.<sup>22</sup> Functional silicone impression materials are a separate group having prolonged manipulative time and appropriate viscosity to allow performing the functional tests.<sup>23,24</sup>

During the clinical impression procedure, the minimum applied pressure is 1 kg/cm<sup>2</sup>, which is unequal distributed - bigger on the alveolar ridge, less on the midline.<sup>25</sup>

## AIM

To determine the accuracy of different impression materials for border molding of individual impression trays.

## MATERIALS AND METHODS

Two thermoplastic and two silicone materials for border-molding were subjected to a laboratory test - impression compound green sticks (Kerr), thermoplastic material GC Iso functional sticks (GC), additive type silicone (Detaseal function - Detax) and condensation type silicon (Sta-seal f - Detax) (Figs 1-4).

It was used modified individual impression tray by author's design. It was made of a two-layer light-polymerizing base plate. In the area of the gingivobuccal sulcus, the vestibular layer was formed 1 mm higher than the palatal and a chase was formed between them as a mechanical retention.

The palatal inclination was filled with material up to alignment with the level of the alveolar ridge. This impression tray was used to taking an impression of a model, obtained using a 3D printer technology with individual values of the gingivobuccal sulcus width and 2 mm depth (Fig. 5).

For proper tempering of thermoplastic materials according to the manufacturer's recommendations, a laboratory setting was invented, including a control box and a water bath. The operating temperature for GC Iso functional sticks was 40°C, for Impression compound green sticks - Kerr - 50°C (Fig. 6).

After manual mixing of the components of silicone materials, the impression mass was shaped like an elongated cylinder and placed at the edges of the individual impression tray. Thermoplastic materials were melted in our Laboratory setting for controlled tempering, and again the material was extended and placed at the custom tray's edge. The composition (a model, an individual impression tray and an impression material) was placed immediately in the hydraulic dental press. The impression material filled the gingivobuccal sulcus on the model. During the elastification / hardening of the impression material, the model and the individual impression tray were loaded with 40 kg (40 bar), corresponding to the minimum pressure impression taking and the prosthesis area. The composition was retained in the press until the complete elastification/hardening of the material. The impression mass that was out of the custom tray was cut off (Figs 7, 8).

10 impressions were taken, and their formed edges were measured at 10 points (5 symmetrical points on each side) three times - immediately after elastification/hardening, and after 24 and 48 hours (Fig. 9).

The results were tabulated, statistically processed and visualized using Microsoft Office Excel 2010.

## RESULTS

ANOVA repetition analysis was used to process the data obtained to compare more than two group means. The results were also confirmed by Tukey, Bonferroni and Duncan's validated tests.

### 1. Impression compound green sticks (Kerr)

According to mean value, there wasn't difference between the three time intervals (2,935 mm). This describes the impression compound as a very stable material (Table 1).

We found no significant differences between the different time measurements for this thermoplastic material (Tables 2, 3).

### 2. GC Iso functional sticks (GC)

The mean value decreased by 0.023 mm for "immediate / 24 hours" interval and 0.014 mm for "24/48 hours" interval. There was a minimal shrinkage, more pronounced in the first 24 hours after the impression taking (0.023 mm) (Table 4).



**Figure 1.** Impression compound\* after border molding procedure.



**Figure 2.** GC Iso functional sticks\*\* after border molding procedure.



**Figure 3.** Detaseal function material\*\*\* after border molding procedure.



**Figure 4.** Sta-seal f material\*\*\*\* after border molding procedure.

\*Impression compound – green sticks (Kerr); \*\*GC Iso functional sticks (GC); \*\*\*Detaseal function (Detax); \*\*\*\*Sta-seal f (Detax)

In the processing of the data obtained from the thermoplastic material *GC Iso functional sticks* no statistically significant difference was found between the different time measurements (Tables 5, 6).

### 3. Detaseal function (Detax)

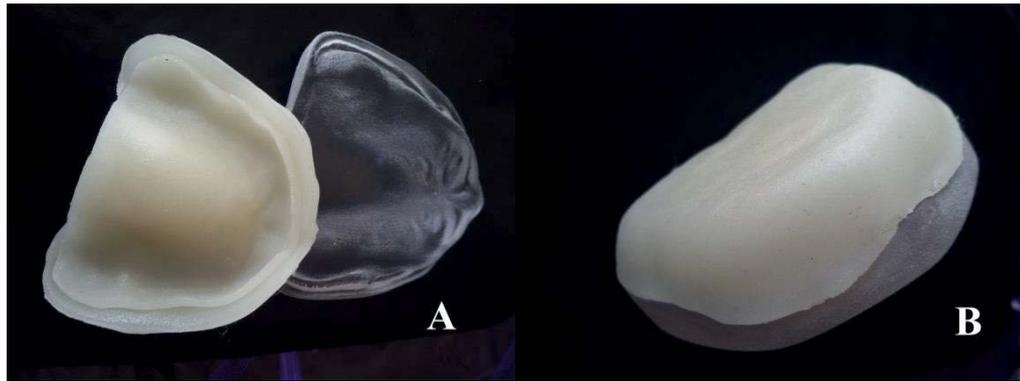
After analyzing the mean values, a minimal shrinkage by 0.02 mm was established in the intervals immediately and after 24 hours, and by 0.023 mm at “24/48 h” interval (Table 7).

There was no significant difference between the different time measurements for the additive type of silicone Detaseal function (Tables 8, 9).

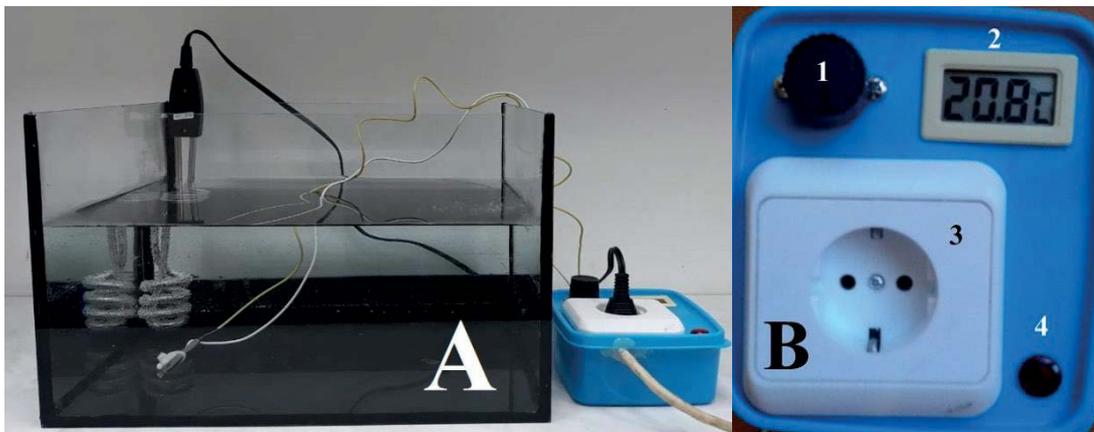
### 4. Sta-seal f (Detax)

From the movement of the mean values it was visible that they decreased and significant shrinkage was established, especially pronounced during the first 24 hours - 0.174 mm. The change was minimal by 0.01 mm in the range between 24 and 48 hours (Table 10).

The data obtained from the condensation type *Sta-seal f silicon* showed a statistically significant difference between the initial moment and the 24 hour sample and the initial moment and the 48 hour sample. A statistically significant difference was not found between 24 and 48 hours (Tables 11, 12).



**Figure 5.** Modified individual impression tray (A) and a model with individual values made on 3D printer technology (B)



**Figure 6.** Laboratory setting for controlled tempering (A) and a control box (B)

1. thermoregulator (5°C – 75°C); 2. digital thermometer; 3. contact for switching on the heater; 4. signal light illuminated when the heater is operating.



**Figure 7.** Laboratory composition of taking an impression.

The observed statistically significant differences are not of clinical relevance for the purpose of border molding the individual impression tray.

An interesting fact is the variability between the average group values of the tested materials. Both thermoplastic and both silicone materials are grouped together with close rates. At the initial moment after hardening / elastification the material, the largest volume has the synthetic resin GC (2.960 mm), followed by Kerr impression compound (2.935 mm). The difference between them was 0.025 mm. With a significantly smaller volume of silicone materials - Sta-seal f (2,753 mm) and Detaseal function (2,690 mm). Their difference was 0.063 mm. However, when comparing the two groups, the difference varies from 0, 18 mm to 0.27 mm. This discrepancy is shown in **Table 13**.

## DISCUSSION

Laboratory tests show accuracy and stability, as described



Figure 8. Laboratory made impression.

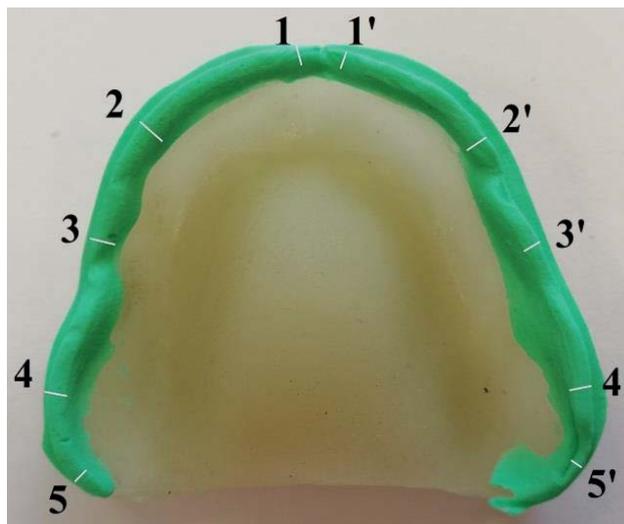


Figure 9. Points of measurement.

Table 1. Statistical descriptive parameters for impression compound green sticks (Kerr)

	Minimum	Maximum	Mean	Standard deviation
Immediately	2.460	3.340	2.935	0.207
After 24 h	2.470	3.340	2.935	0.208
After 48 h	2.470	3.360	2.935	0.208

Table 2. ANOVA repetition analysis for impression compound green sticks – Kerr

Source	DF	Sum of squares	Mean squares	F	Pr > F	Adj. Pr>F G-G	Adj. Pr>F H-F
Repetition	2	0.000	0.000	0.161	0.851	0.840	0.844
Error	198	0.015	0.000				

Table 3. Tukey test to establish a difference between time intervals (Impression compound green sticks Kerr)

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
now/24 hours	0.001	0.024	2.356	1.000	No
now/48 hours	0.000	0.010	2.356	1.000	No
24 h/48 h	0.000	0.014	2.356	1.000	No
Tukey's d critical value:			3.331		

Table 4. Statistical descriptive parameters for GC Iso functional sticks (GC)

	Minimum	Maximum	Mean	Standard deviation
Immediately	2.550	3.460	2.960	0.213
After 24 h	2.540	3.440	2.937	0.213
After 48 h	2.520	3.420	2.923	0.214

**Table 5.** ANOVA repetition analysis for GC Iso functional sticks

Source	DF	Sum of squares	Mean squares	F	Pr > F	Adj. Pr>F G-G	Adj. Pr>F H-F
Repetition	2	0.069	0.034	864.510	< 0.0001	< 0.0001	< 0.0001
Error	198	0.008	0.000				

**Table 6.** Tukey test to establish a difference between time intervals (GC Iso functional sticks)

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
now/24 hours	0.037	1.223	2.356	0.441	No
now/48 hours	0.022	0.734	2.356	0.743	No
24 h/48 h	0.015	0.491	2.356	0.876	No
Tukey's d critical value:			3.331		

**Table 7.** Statistical descriptive parameters for Detaseal function (Detax)

	Minimum	Maximum	Mean	Standard deviation
Immediately	2.220	3.100	2.690	0.212
After 24 h	2.190	3.090	2.670	0.212
After 48 h	2.170	3.070	2.647	0.212

**Table 8.** ANOVA repetition analysis for Detaseal

Source	DF	Sum of squares	Mean squares	F	Pr > F	Adj. Pr>F G-G	Adj. Pr>F H-F
Repetition	2	0.094	0.047	790.074	< 0.0001	< 0.0001	< 0.0001
Error	198	0.012	0.000				

**Table 9.** Tukey test to establish a difference between time intervals (Detaseal function Detax)

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
now/24 hours	0.043	1.444	2.356	0.320	No
now/48 hours	0.021	0.696	2.356	0.766	No
24 h/48 h	0.022	0.747	2.356	0.736	No
Tukey's d critical value:			3.331		

**Table 10.** Statistical descriptive parameters for Sta-seal f (Detax)

	Minimum	Maximum	Mean	Standard deviation
Immediately	2.200	3.230	2.753	0.249
After 24 h	2.080	3.110	2.579	0.248
After 48 h	2.080	3.090	2.569	0.247

**Table 11.** ANOVA repetition analysis for Sta-seal f

Source	DF	Sum of squares	Mean squares	F	Pr > F	Adj. Pr>F G-G	Adj. Pr>F H-F
Repetition	2	2.145	1.073	1255.161	< 0.0001	< 0.0001	< 0.0001
Error	198	0.169	0.001				

**Table 12.** Tukey test to establish a difference between time intervals (Sta-seal f Detax)

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
now/24 hours	0.184	5.244	2.356	< 0.0001	Yes
now/48 hours	0.175	4.966	2.356	< 0.0001	Yes
24 h/48 h	0.009	0.269	2.356	0.961	No
Tukey's d critical value:			3.331		

**Table 13.** Mean values of the tested materials.

	GC Iso functional sticks	Kerr impression compound green	Sta-seal f	Detaseal function
immediately	2.960	2.935	2.753	2.690
after 24 h	2.937	2.935	2.579	2.670
after 48 h	2.923	2.935	2.569	2.647

by other authors. The type of the polymerization reaction and the release of the side products in the condensation silicones show a change in their volume. The established significant difference in linear stability of the condensation silicones during the first 24 hours was confirmed by other authors.<sup>19,20</sup> The deviation and linear change are not the same in the three dimensions of the impression.<sup>21,22</sup> In the additive reaction due to the breakage of double and triple bonds in the polymer chain, such side product is not observed and the volume accuracy is preserved.<sup>14,24</sup> Our investigation confirmed the statement that additive type silicones are stable up to 48 hours after impression taking.<sup>18,19</sup>

The resulting hardness of the two thermoplastic materials confirms their basic application in unretentive alveolar ridges, whereas the elasticity of the two silicone materials allows their application in retentive.<sup>14,15,24</sup> To preserve the properties of the thermoplastic materials tested, it is advisable to melt them at a temperature specified by the manufacturer.<sup>23,24</sup> The thermoplastic impression materials have impressed the projection of the gingivobuccal sulcus more widely than the silicones. A similar study also shows that thermoplastic materials impressed the area wider but also shorter than A-silicone.<sup>7</sup> In literature, the impression compound possesses 0.3-0.5% linear shrinkage, which is not confirmed of our results.<sup>15</sup> In a combined study, it was

found that the impression compound gave the largest variation in width, the wax - in the area.<sup>8</sup>

When comparing the final result of complete dentures made after impression taking with impression compound and A-silicone, no statistically significant difference was found.<sup>22</sup> Some authors observed a significant difference in retentive effect using impression compound and A-silicone,<sup>16</sup> others did not detect it<sup>17</sup>. For patients' satisfaction is important the stability, phonetics, volume of a construction and balanced occlusion, which are indirectly related to the type of the impression material.<sup>4,5,16</sup>

## CONCLUSION

Border molding procedure is important part of complete dentures fabrication and it is related to the final result. Depending of anatomical features can be used different impression materials. Good manipulative qualities and measured accuracy in laboratory tests define these materials as very good for using in border molding procedure and represent a method of choice in the clinical shaping of the edge of the individual impression tray. The statistically significant difference in condensation type silicone is not clinically significant.

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# Лабораторное исследование точности оттискных материалов для функционального формирования краёв

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**Введение:** Функциональное формирование края индивидуальной ложки является важным этапом протезирования беззубых челюстей, от которого часто зависит конечный результат лечения. Классические термопластичные оттискные материалы функционального формирования обладают положительными качествами, которые делают их предпочтительными для врачей из-за их жёсткости, неограниченного времени манипуляции и высокой чёткости оттиска. Современные силиконовые функциональные оттискные материалы имеют длительное время обработки и адекватную вязкость, что позволяет стоматологам проводить функциональные тесты.

**Цель:** Определить точность различных оттискных материалов для функционального формирования индивидуальных ложек.

**Материалы и методы:** В лаборатории были испытаны четыре типа оттискных материалов для функционального формирования: термопластичный материал Kerr impression compound green sticks и GC Iso functional sticks, силиконовый материал Detaseal function и конденсационный силикон sta-seal f. Была использована модифицированная индивидуальная оттискная ложка, изготовленная авторами, которая обеспечивала лабораторную нагрузку и стабильность. Было снято десять оттисков, и их края были измерены в 10 точках три раза - сразу после затверждения / эластификации и через 24 часа и 48 часов после затверждения / эластификации.

**Результаты:** Результаты были проанализированы с помощью дисперсионного анализа ANOVA repetition для сравнения более двух средних групп, которые обнаружили статистически незначимое различие в точности трёх оттискных материалов для функционального формирования, кроме силикона C-type.

**Выводы:** Хорошие качества обработки и измеренная точность при лабораторных испытаниях позволяют утверждать, что эти оттискные материалы очень хороши для процедур функционального формирования.