Influence of Extended Setting Time On Permanent Deformation Of Elastomeric Impression Materials: An In Vitro Study

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ABSTRACT

The purpose of this study was to check the influence of extended setting time on permanent deformation for 5 vinyl polysiloxane materials (Flexceed, Imprint II Garant, Aquasil Ultra LV, AFFINIS PRECIOUS, Elite HD+) and 1 polyether (Impregum Soft). Specimens (n=10) were fabricated in a brass mold and loaded in tension with a crosshead speed of 200 mm/min to 80% strain. Change in length measured after 2 hours. Influence of storage time was tested by t test. Correlation between tests was evaluated using Pearson’s correlation coefficient. The results of the present study showed that permanent deformation in Impregum Soft was reduced from 2.53% to 0.98%. For Flexceed it reduced from 1.69% to 0.896% and from 0.88% to 0.35% in case of Elite HD+. It was concluded that extending the intraoral time can reduce permanent deformation in case of Flexceed (GC), Elite HD+ and Impregum Soft (3M) polyether.

Keywords: Elastomers, Dimensional accuracy, Setting time, Polyether

INTRODUCTION

Impression making is an essential step during fixed prosthodontic treatment procedures, as the quality of an impression significantly affects the accurate fit of the definitive restoration. Impression materials must have sufficient strength to allow removal from a gingival sulcus without tearing. To accurately replicate a tooth structure, impression material must not permanently deform while being removed from the oral cavity. A fundamental property of an elastomeric impression material, which significantly influences an impression’s accuracy, is its elastic recovery from deformation. Permanent deformation can be related to the viscoelastic properties inherent in elastomeric impression materials. Extending the intraoral setting time may improve the elastic properties of the polymerized impression material, due to a higher degree of polymerization, and reduce the risk of permanent deformation and inaccuracies. So the purpose of this study was to investigate the effect of the chemistry and extended setting time on the permanent deformation of light-body impression materials after stretching.

MATERIALS AND METHODOLOGY

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Material</th>
<th>Manufacturer</th>
<th>Lot. No.</th>
<th>Chemical Type</th>
<th>Manufacturer’s Recommended Setting Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Affinis Precious Light Body</td>
<td>Coltène/Whaledent AG, Altstätten, Switzerland</td>
<td>H02189</td>
<td>Vinyl polysiloxane</td>
<td>2 min.</td>
</tr>
<tr>
<td>2.</td>
<td>Aquasil Ultra LV Regular Set</td>
<td>DentsplyDeTrey GmbH, Konstanz, Germany</td>
<td>160505</td>
<td>Vinyl polysiloxane</td>
<td>5 min.</td>
</tr>
<tr>
<td>3.</td>
<td>Elite HD+ Normal Set</td>
<td>Zhermack, Italy</td>
<td>191079</td>
<td>Vinyl polysiloxane</td>
<td>3min.30sec</td>
</tr>
</tbody>
</table>
A custom made dumb-bell shaped metallic mold with a width of 4mm and thickness of 2 mm was used for sample preparation. It consisted of a 20-mm-long section of the inner bar delineated by four V-shaped notches.

![Figure 1: Schematic drawing of specimen configuration (upper: top view; lower: side view). Dimensions: l = distance between measuring marks (20 mm); w = width (4 mm); h = height (2 mm); o = overall length (75 mm).](image)

The mold was placed over a metal slide and the impression materials were directly dispensed using an automix dispenser gun via the mixing tip, into the dumbbell-shape mold (fig.1). Impregum soft used in the study was a two-paste system it was manually mixed using a mixing spatula over a mixing pad. Equal lengths of base and catalyst were dispensed over the mixing pad and mixed until a homogenous color was obtained (fig.2). This mix was then loaded into the mold with spatula. Once the mold was filled with impression material the mold was covered with another metal slide. This whole assembly consisting of the metal mold placed between two metal slides was then clamped. The clamp was tightened until uniform contact between the metal slides and the metal mold was obtained to get specimens of uniform thickness.

![Figure 2: Sample preparation for Vinyl Polysiloxane](image)

![Figure 3: Sample preparation for Polyether](image)
The clamped assembly was then taken out placed in a thermostat controlled water bath (CLL-IDR-EQ-M-690), preadjusted to a temperature of 35°C. Time for which the specimen was to be kept under water bath varied according to the manufacturer’s suggested intra oral setting time.

After removal from the water bath, the specimens were removed from the metal mold and flash was removed using a Bard Parker knife. Subsequently (1.5 minutes following removal from the water bath), the specimens were clamped in a tension-free manner in a universal testing machine (MODEL: DUTT-105) and stretched to 60% of their original length at a crosshead speed of 200 mm/min. The tensile load was removed after 2 seconds and the specimens returned to their initial length and were stored in room temperature air to allow unrestrained dimensional changes in ambient laboratory conditions for 2 hours (± 10 minutes), and aligned to a transparent plastic pane on the XY stage of a stereomicroscope (MODEL: DQS 0745-T). The distance between both measuring marks on each side was determined 3 times at 40x magnification, and mean values were calculated.

**Statistical Analysis**

The present study consisted of 120 dumbbell shape light body viscosity impression material (5 types of vinyl polysiloxane and one polyether) samples, divided into six test groups and six control groups.

The data were subjected to a Levene test to check for homogeneity of variances. The mean values and standard deviation were calculated. A two-way ANOVA was used to test the influence of the impression material and storage time. The influence of storage time was tested for each material using a t test for unpaired sample groups. All statistical analyses were carried out at a significance level of 0.05 and performed under statistical software MStat C.

**OBSERVATION AND RESULT**

Twenty samples of each material were taken and divided into test and control group. The permanent deformation was calculated by following formula:

\[
\text{dl} = \frac{l_1 - l_0}{l_0} \times 100
\]

where:
- \( \text{dl} \) is the percentage of permanent deformation,
- \( l_1 \) is the length of specimen after stretching (in mm) and
- \( l_0 \) is the original length of specimen.

A prolongation of specimen storage time in water significantly reduced the permanent deformation in 4 of the 6 materials tested \((p<0.05)\). Both the impression material and storage time had a significant influence on the permanent deformation (Table 3). In addition, the impression material and the storage time influenced the permanent deformation in interaction \((p<0.001)\). The results of the present study showed that permanent deformation of Impregum Soft was maximum (2.53%) while it was minimum in case of Elite HD+ (0.43%). Extending the setting time significantly improved the dimensional accuracy of Impregum Soft (IsT), Imprint II Garant (IMT) and Flexceed (FIT).

The permanent deformation in Impregum Soft was reduced from 2.53% to 0.98%. In case of Flexceed it reduced from 1.69% to 0.896% and from 0.88% to 0.35% in case of Elite HD+. A reduction in permanent deformation of Aquasil Ultra LV was also seen but the result was not significant \((p>0.05)\) (table 2).

**Table 2: Mean values and standard deviation of permanent deformation (dl%)**

<table>
<thead>
<tr>
<th>Product</th>
<th>Tested Mean</th>
<th>±SD</th>
<th>Control Mean</th>
<th>±SD</th>
<th>‘t’ value</th>
<th>‘p’ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquasil ultra</td>
<td>0.507</td>
<td>0.375(^a)</td>
<td>0.732</td>
<td>0.347(^a)</td>
<td>1.390</td>
<td>0.180NS</td>
</tr>
<tr>
<td>Elite HD</td>
<td>0.630</td>
<td>0.467(^b)</td>
<td>0.432</td>
<td>0.276(^b)</td>
<td>0.842</td>
<td>0.410NS</td>
</tr>
<tr>
<td>Affinis – Coltene</td>
<td>0.618</td>
<td>0.466(^b)</td>
<td>0.466</td>
<td>0.218(^b)</td>
<td>0.627</td>
<td>0.538NS</td>
</tr>
<tr>
<td>Imprint II Garant</td>
<td>0.357</td>
<td>0.223(^c)</td>
<td>0.886</td>
<td>0.440(^c)</td>
<td>2.73</td>
<td>0.013Sig</td>
</tr>
<tr>
<td>Flexceed</td>
<td>0.896</td>
<td>0.230(^c)</td>
<td>1.698</td>
<td>0.567(^d)</td>
<td>4.14</td>
<td>0.000HS</td>
</tr>
<tr>
<td>Impregum</td>
<td>0.980</td>
<td>0.547(^d)</td>
<td>2.538</td>
<td>0.664(^d)</td>
<td>2.92</td>
<td>0.009HS</td>
</tr>
</tbody>
</table>
Table 3: Results of the 2-way Anova to identify influence of material and storage time on permanent deformation of materials tested

<table>
<thead>
<tr>
<th>Source</th>
<th>Df</th>
<th>Sum of squares</th>
<th>Mean sum of squares</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>5</td>
<td>26.32</td>
<td>5.26</td>
<td>12.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Storage</td>
<td>1</td>
<td>6.36</td>
<td>6.36</td>
<td>14.68</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Material x storage</td>
<td>5</td>
<td>10.94</td>
<td>2.19</td>
<td>5.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Error</td>
<td>99</td>
<td>42.89</td>
<td>0.433</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>88.47</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Comparison between the elastic deformation of test and control group to show the percent improvement in dimensional stability of test group

<table>
<thead>
<tr>
<th>Product</th>
<th>Tested</th>
<th>Control</th>
<th>% reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquasil ultra</td>
<td>0.507</td>
<td>0.732</td>
<td>30.7</td>
</tr>
<tr>
<td>Elite HD</td>
<td>0.630</td>
<td>0.432</td>
<td>-45.8</td>
</tr>
<tr>
<td>Affinis - Coltene</td>
<td>0.618</td>
<td>0.466</td>
<td>-32.6</td>
</tr>
<tr>
<td>Imprint II garant</td>
<td>0.357</td>
<td>0.886</td>
<td>59.7</td>
</tr>
<tr>
<td>Flexceed</td>
<td>0.896</td>
<td>1.698</td>
<td>47.2</td>
</tr>
<tr>
<td>Impregum</td>
<td>0.980</td>
<td>2.538</td>
<td>61.4</td>
</tr>
</tbody>
</table>

Graph I: Mean values of permanent deformation of test and control group

Graph II: Comparison of mean values of permanent deformation of control group
DISCUSSION
Poly (vinyl siloxane) (PVS), or addition silicone impression materials are known for their excellent elastic recovery, accuracy, adequate tear resistance, satisfactory handling characteristics and nearly ideal dimensional stability. The international standard for dental elastomeric impression materials states that a type III (light body) impression material must reproduce a line 0.020 mm in width. With the exception of the very high viscosity putty materials, all polyvinyl siloxanes (light, medium and heavy body) achieve this.

In the current study, the manufacturer recommended setting time (table 1) were used as the baseline/control group and the test group had extended setting times mentioned as per the previous studies by Eugene W. Skinner and Edwin N. Cooper in 1955, C. W. Fairhurst et al in 1956, Miller et al in 1960, Victoria A. Marker in 1990.

Specimens identical to those suggested for rubber testing by ASTM (American Society for Testing and Materials), test No. D4121 were prepared using an aluminum mold that yields a “necked” specimen, having a “dog bone” shape. The temperature of the water bath used in the present study was 35 °C to simulate the oral conditions as the dimensional changes at intra oral temperature are more than that at room temperature.

Elongation/stretching of the elastomeric sample in the current study were performed rapidly at a cross head speed of...
200mm/min to simulate the intraoral removal of impression. 

The results of the present study showed that permanent deformation of Impregum Soft was maximum at about 2.53% while it was minimum in case of Elite HD+ i.e. 0.43%. Extending the setting time significantly improved the dimensional accuracy of Impregum Soft, Imprint II Garant and Flexceed. The permanent deformation in Impregum Soft was reduced from 2.53% to 0.98%. In case of Flexceed it reduced from 1.69% to 0.896% and from 0.88% to 0.35% in case of Elite HD+.

With elastomers, there is no discernible yield point or proportional limit as there is with alloys. Elastomers deform to some extent soon after extension, and the point of significant deformation may be different for each clinical use. Nevertheless, the purpose of the study was not to define a precise point, but rather to compare the dimensional stability of six materials. Although prolonged polymerization in temperature controlled waterbath for 5 minutes significantly reduced the permanent deformation for the majority of the products tested, the improvement in elastic recovery may or may not be clinically significant. This study also showed that the elastic recovery of polyether Impregum Soft is low as compared to vinyl polysiloxanes.

CONCLUSION

Within the limitations of this in vitro study, the following conclusions were made:

1. Extending the intraoral time of elastomeric impression material can reduce permanent deformation of elastomeric materials in case of Flexceed (GC), Imprint II Garant (3M) and Impregum Soft (3M) polyether.
2. Permanent deformation when using the manufacturer’s setting time for the 6 materials tested decreases in the following order:
   Impregum Soft > Flexceed > Imprint II Garant > Aquasil Ultra LV > AFFINIS PRECIOUS > Elite HD+.
3. Permanent deformation when using an extended setting time for the 6 materials tested decreases in the following order:
   Impregum Soft > Flexceed > Elite HD+ > AFFINIS PRECIOUS > Aquasil Ultra LV > Imprint II Garant.

REFERENCES
