Dimensional Accuracy of Different Impression Materials and Techniques Commonly Used In Prosthodontics

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ABSTRACT

Introduction: The successful fabrication of indirect restorations largely depends on an accurate impression from which a replica of the intraoral structures can be precisely created. Therefore for accurate reproduction of the preparation margins in impression proper choice of impression material and technique is very important.

Objective: The objective of this in vitro study was to evaluate and compare the dimensional accuracy of the cast obtained from different impression materials and techniques commonly used in fixed prosthodontics.

Materials and Method: The impressions were made from a metallic master model made of stainless steel that simulated a tooth preparation for mandibular molar. The following impression materials were evaluated: polyvinyl siloxane in one-step dual viscosity technique (group 1), polyvinyl siloxane in two-step dual viscosity technique (group 2), laminated reversible/irreversible hydrocolloid impression technique (group 3) and improved alginate (group 4). Dimensional changes (mm) were assessed between the master model and the stone model (type IV gypsum) at two reference points marked in the mesiodistal and buccolingual surfaces. The measurements of the master model and stone model were made with digital micrometer (accuracy of 0.001 mm).

Result: The stone dies obtained with all the materials and techniques had significantly larger dimensions as compared to the master model (p<0.05). The lowest to highest deviation from the master model was found to be group 2, group 1, group 3 and highest deviation was shown by group 4. One way analysis of variance revealed no significant differences in dies obtained from the different groups of the impression. In comparison with the two techniques for the polyvinyl siloxane material two-step dual viscosity was more accurate than one-step dual viscosity technique.

Conclusion: Different impression materials and techniques which are commonly available and used in fixed prosthodontics are accurate and can provide satisfactory clinical results when they are used in the correct method.

Keywords: Alginate; dimensional accuracy; impression materials; laminated hydrocolloid technique, polyvinyl siloxane.
INTRODUCTION

Precise tooth preparation and accurate fit of the prosthesis on the prepared abutment teeth are the basic needs in fixed prosthodontics. The purpose of impression material is to record the dimensions of teeth and their surrounding oral structure in their correct relationship. A material which is in a soft state is placed against the oral tissues and allowed to harden and set which gives the negative reproduction. A positive reproduction is obtained by pouring dental stone into this impression which is known as either a model or a cast.

Indirect restorations for example crowns, inlays and fixed prosthesis are fabricated on these casts and models. The successful fabrication of indirect restorations largely depends on an accurate impression from which a replica of the intraoral structures can be precisely created. Therefore accurate reproduction of the preparation in impression is very important for the success of the prosthesis.

Although a number of materials and techniques have provided adequate clinical results, the ideal impression material has not yet been found.

There are several impression materials available for the use in fixed prosthodontics for e.g. hydrocolloids which include agar and alginate; synthetic elastomeric materials including polysulfide, condensation silicone, addition silicone and polyether. Often the choice of impression material depends upon the subjective choice of the operator based on personal preferences, handling, past experience with particular materials.

Despite technical improvements in the field of computer aided designing/computer aided manufacturing (CAD/CAM) system and 3-dimensional (3-D) imaging procedure conventional impressions are still required for transporting information from the dentist to the dental laboratory. In the future, intraoral chairside intraoral scanners (e.g. the CEREC- Sirona dental systems) might replace the need for making impressions. But until such system is developed the conventional impression making is one of the crucial steps in the fixed prosthodontics.

The main aim of this study was to compare the dimensional accuracy of the most commonly used impression material and technique for the fixed prosthodontics so that this study can be a guide for the selection of various impression materials and techniques.

MATERIALS AND METHOD

The impression materials used in the present study and their details are presented in following:

<table>
<thead>
<tr>
<th>Material</th>
<th>Trademark</th>
<th>Manufacturer</th>
<th>Pouring time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition silicone</td>
<td>Silagum putty and light body</td>
<td>DMG</td>
<td>1 hour</td>
</tr>
<tr>
<td>Modified Alginate</td>
<td>Neocolloid</td>
<td>Zhermark</td>
<td>immediate</td>
</tr>
<tr>
<td>Agar</td>
<td>Ji Jing Agar</td>
<td>Nissin Dental Products Inc., Japan</td>
<td>immediate</td>
</tr>
<tr>
<td>Alginate</td>
<td>Jeltrate</td>
<td>Zhermark</td>
<td>immediate</td>
</tr>
</tbody>
</table>

A stainless steel master model was prepared representing a single tooth preparation of the mandibular first molar. The die was firmly attached to a base and platform made of the stainless steel so that it is immobilized during the impression making. The die was marked with the reference grooves of 0.5 mm depth on the axial surface. Circumferential reference line was made 1 mm from the occlusal surface. The surface of the stainless steel die was highly polished to eliminate the need of separator and minimize cleaning. Perforated Stock impression tray was designed. The edges of the tray fit into the 3mm deep orientation base placed on the platform so that tray could be seated in the same position repeatedly in a self limiting way in each impression. Approximately 7 mm of clearance was present between the impression tray and the die for sufficient bulk of the impression material. A handle was placed on the outer surface of the tray parallel to the long axis of the die so that there is a constant vertical path of insertion and removal during the procedure. The measurement of the master models was used as controls.
Impression Making: The impression material were grouped as follows

**Group 1:** Single mixed polyvinyl siloxane

**Group 2:** Double mixed polyvinyl siloxane

**Group 3:** Improved alginate impression material

**Group 4:** Laminated hydrocolloid technique

Ten impressions were made from each group resulting in a total of 40 impressions. Handling of each of the materials was done according to the manufacturer’s instruction in respect to water powder ratio, mixing time. The impressions were fabricated by one operator that closely approximated the steps used in clinical settings.\(^5\)

**Group 1 (rubber base 1 step)**

The impression was made with putty and light body materials simultaneously. The light body material was dispensed for the automatic mixing syringe. The light body material was injected around and on the occlusal surface of the master model. Simultaneously the putty impression material base and catalyst was hand mixed until the color was homogenous and loaded in the impression tray. The tray filled with the putty material was placed over the master model injected with the light body. The impression material was kept for a longer duration of time than recommended by manufacturer to allow complete polymerization and setting at the room temperature. The impression was then separated from the master model with single axial movement after 10 minutes. It was stored at room temperature for 1 hour before pouring for the following reasons:

1. To allow elastic recovery of the elastomeric material
2. Release of hydrogen form the vinyl polysiloxane

**Group 2 (rubber base 2 step)**

In this technique, to control the thickness of the light body material a layer of wax (1mm) was adapted on the master model. A preliminary impression was made with the putty material in the impression tray. The base and catalyst was dispensed in equal amount and hand mixed until homogenous color was obtained and loaded in the impression tray.

**Group 3 (improved alginate impression material)**

Neocolloid alginate (Zhermack S.p.a, Via Bovazecchino4 5021 Badia Polesine (RO) Italy) was used. Distilled water at room temperature was used for mixing the alginate. The mixing ratio was followed according to the manufacturers instruction. The portions of powder of alginate were weighed in a weighing machine to an accuracy of 0.1gm

Mechanical mix was carried out in Algha mix II. The mixed material was seated and held in place for a longer duration of time than recommended in the manufacturer’s instruction, since the experiment was conducted in room temperature which is lower than mouth temperature, the setting time would be longer. The impression was removed with a straight pull directed along the path of the withdrawal.

**Group 4 (laminated hydrocolloid technique)**

The impressions were made using agar alginate impression material. The tubes of agar were placed into the hydrocolloid conditioner and warmed for 45 minutes before use. Alginate impression material was mixed in automatic mixer (Algha mix) for 10 to 16 seconds. About 10% more water was used while mixing the alginate to make it more fluid in consistency so that alginate and agar material bind properly. The agar impression material was syringed from a cartridge into the margin and occlusal surface of the die. The stock tray containing the mixed alginate was seated over the die injected with the agar impression material. Impression were poured with type IV die stone immediately and left for 1 hour before separating.

**Die preparation:** Die stone type IV (Heraeus Kulzer) was hand mixed in 0.19 water powder ratio. The impression was poured in mechanical vibration to avoid incorporating bubbles in the die.
At one hour after the start of dental stone mixing the die was removed from the impression. It was stored at room temperature for at least 24 hours before the measurements were carried out.

**Measurement:** Measurements were made using a digital micrometer (electronic micrometer, Xibe) with an accuracy of 0.001 mm. The master model and the gypsum dies were measured by a principle investigator. Each dimension on the master model was measured 10 times to record the standard measurements. The average value obtained was used as standard value for the master model to which all dimensions from the gypsum die were compared.

Each dimension of a gypsum die was measured 3 times and an average was taken. The measurements were made by principle investigator. Results were expressed as a difference in millimeters between the gypsum and master model dimensions. The readings were obtained and subjected to statistical analysis.

**Statistical Analysis:** Using Simple calculation, percentage dimensional change in the diameter was calculated as follows:

\[ \Delta d = \left( \frac{\text{Control mean diameter} - \text{cast material mean}}{\text{Control mean diameter}} \right) \times 100 \]

Independent t test was used to compare the dimensional accuracy between the master models and each of the impression technique. One way analysis of variance (ANOVA) was used to compare the dimensional changes of the 4 groups of the impression techniques and materials. Statistical analysis was conducted with SPSS statistical software IBM SPSS version 20 and was considered statistically significant at P value of <0.05.
RESULT

Table 1: Mean and standard deviation of stainless steel master model.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Mean value</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesiodistal</td>
<td>9.258</td>
<td>0.005</td>
</tr>
<tr>
<td>Buccolingual</td>
<td>6.713</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Table 2: Mean and standard deviation of stone dies obtained from the four groups.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Mean diameter MD (SD)</th>
<th>Percent change</th>
<th>Mean diameter BL (SD)</th>
<th>Percent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber base 1 step</td>
<td>9.274 (0.009)</td>
<td>0.182</td>
<td>6.742 (0.016)</td>
<td>0.167</td>
</tr>
<tr>
<td>Rubber base 2 step</td>
<td>9.268 (0.008)</td>
<td>0.108</td>
<td>6.737 (0.006)</td>
<td>0.103</td>
</tr>
<tr>
<td>Laminated technique</td>
<td>9.278 (0.017)</td>
<td>0.221</td>
<td>6.745 (0.015)</td>
<td>0.217</td>
</tr>
<tr>
<td>Alginate</td>
<td>9.286 (0.027)</td>
<td>0.306</td>
<td>6.750 (0.026)</td>
<td>0.294</td>
</tr>
</tbody>
</table>

Figure 7: Percentage dimensional change.

Independent t test revealed significant difference between the master model and all the groups of the impression materials (P<0.05). The materials were larger than the master model except for the buccolingual dimensions in group 1 and group 2 (p >0.05)

Table 3: Analysis of variance within groups of different impression materials (ANOVA).

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>buccolingual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>.001</td>
<td>3</td>
<td>.000</td>
<td>.920</td>
<td>.441</td>
</tr>
<tr>
<td>Within Groups</td>
<td>.011</td>
<td>36</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>.012</td>
<td>39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mesiodistal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>.002</td>
<td>3</td>
<td>.001</td>
<td>1.884</td>
<td>.150</td>
</tr>
<tr>
<td>Within Groups</td>
<td>.011</td>
<td>36</td>
<td>.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>.013</td>
<td>39</td>
<td></td>
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</tbody>
</table>

It shows that there is no significant difference between the different impression materials and techniques conducted in this study.
DISCUSSION

In the present study, the accuracy of four groups of impression materials and techniques was investigated. For all groups the stone dies were generally larger than the master model (p<0.05). This finding is supported by the other researches. Group 2 impression material i.e. polyvinyl siloxane with the double mixed technique showed the highest accuracy with the minimal percentage deviation from the master model. Alginate showed the highest variation in both the mesiodistal (0.306%) and buccolingual (0.294%) dimension.

Similar to results of many other studies, present study also showed that silicone impression materials showed greater accuracy and stability than the alginate impression material and reversible hydrocolloids. In a study of comparison between different impression materials it was found that laminated hydrocolloid and double mix polyvinyl siloxane was much more accurate than alginate. The authors have also concluded that laminated hydrocolloid technique has some superior quality than polyvinyl siloxane and it can be the technique of choice in clinical practice.

Heering and Tames studied the dimensional accuracy of laminated hydrocolloid technique. They suggested that dimensional accuracy is clinically acceptable. Similarly in another study by Fusayama they have mentioned that laminated hydrocolloid indirect impression technique is simple, accurate, and eliminates the disadvantages of both impression materials i.e. agar and alginate materials when used individually.

Among the other material tested in this study alginate is the most popular in clinical practice mainly because of two factors: low cost and ease of use. Studies that compared alginate and elastomeric impression materials have found statistically different results for alginates. The instability of alginate through time and its surface roughness because of water loss are disadvantages limiting the use of the alginates for diagnostic casts. To overcome the disadvantages improved alginate is developed. The alginate used in the present study which is improved alginate is designed for the use fixed prosthodontics. In the present study although the alginate shows the largest variation among other impression materials the variation is within the acceptable limits. In present study statistically there was no significant difference between the other groups and the improved alginate.

Similar to the results of present study in some other studies the accuracy of reversible hydrocolloids and elastomeric impression, hydrocolloids have produced casts of comparable accuracy with that of the elastomeric impression materials.

Eriksson et al evaluated one agar, seven alginates and two addition silicones. The results indicated that irreversible hydrocolloids designed for fixed prosthodontics which are poured within 2 hours have accuracy similar to the tested reversible hydrocolloid and addition silicones, which are the two most commonly used impression materials. Thus they concluded that some irreversible hydrocolloid could be an alternative impression material for clinical use in fixed prosthodontics.

From the various studies it has been concluded that improved alginate is also a good alternative to elastomeric impression and the reversible hydrocolloid impression material. So the present study aims for checking the feasibility of the use of modified alginate technique in fixed partial dentures. This study was carried out to determine which of the four techniques yielded the best result and the objective is achieved by measuring the width of the stone dies obtained from various impression techniques and comparing the dimensional changes to the original master model.

In the present study between the one-step and the two-step technique for the rubber base impression, two-step technique is more accurate than one-step technique. The one-step technique has the advantage of simplicity and reasonable economy, but in this technique the putty tends to push the light body wash off the margins of the prepared tooth thus the most critical areas like finish lines will be recorded to an unsatisfactory level. Other drawback of the one-step technique is that once the light body material is injected on the preparation, the putty should be brought into position and seated. During this period the patients tongue or the elevated floor of the mouth can remove light body from the tooth.

The best result in the present study was seen for the two step technique. This can be related to the sufficient wash obtained through the use of the
light body material. Studies have shown that bulk wash of 1-2 mm perform significantly better than a bulk wash of 4 or 6 mm in terms of dimensional accuracy. 21

CONCLUSION

The dimensional changes were evident with all the four impression techniques conducted in this study however the magnitude of the changes was of negligible clinical significance. All the impression materials and techniques implied in this study showed small differences and well within the reported ANSI/ADA standards. Within the limitation of the study this can be concluded that Polyvinyl siloxane was more accurate than laminated hydrocolloid technique and the improved alginate and among the two techniques for the dual viscosity poly vinyl siloxane, 2-step impression technique was more accurate than 1-step impression technique.

Statistically there was no significant difference between the different groups of impression materials conducted in this study.

REFERENCES