A Clinical Evaluation of the Agar Alginate Combined Impression: Dimensional Accuracy of Dies by New Master Crown Technique

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Purpose: To evaluate the dimensional accuracy of several impression methods including agar alginate combined impression in vivo; the marginal accuracy of stone dies was determined using a new electroformed master crown technique.

Materials and Methods: Cast cores with knife-edge and chamfer margins and electroformed master crowns were fabricated for 3 patients. Five impressions were taken of each preparation, using agar alginate combined impression and silicone impression materials. Dies were made after impression. The marginal fit of the master crown on each die was analyzed by four-way analysis of variance (ANOVA) and Tukey HSD test (p<0.05).

Results: The marginal fit of the master crown on the dies with chamfer margin was better than those with knife-edge margin for agar alginate combined impression. The shape of the margin did not affect the accuracy when silicone impression material was used.

Conclusions: The results suggest that the agar alginate impression method is clinically acceptable for the chamfer margin, but shape of the margin may affect the dimensional accuracy of dies. The shape of the margin does not affect the accuracy of dies when silicone impression was used. Furthermore, the master crown made by electroforming technique could be useful for clinical evaluation of impression methods.

Key words: dimensional accuracy, agar alginate combined impression, electroformed crown, master crown

Introduction

Dimensional accuracy of an impression material is important to fabricate restorations with good adaptation. Agar alginate combined impression method produces impressions with good surface details. Accuracy can be achieved when they are handled properly and immediately poured with compatible stone.

After the development of the impression procedure using a combination of reversible hydrocolloid with irreversible hydrocolloid to take impressions for restora-
tions in Japan, this method has been widely used and introduced abroad. The advantages of reversible with irreversible hydrocolloid impressions are (1) Inexpensive (2) Less preparation time, (3) Relatively hydrophilic, (4) Easy manipulation, compared with other impression systems.

Many basic studies on this method have been reported. Especially dimensional accuracy and bond strength have been extensively studied. These studies have shown that combination hydrocolloid impression materials are as accurate as elastomeric impression materials. The distortion of combined hydrocolloids was considered to be clinically acceptable.

However, according to a recent report the dentists using this impression method daily in their clinic were not necessarily satisfied with its accuracy. Master crowns are used to evaluate the accuracy of margin in the studies done in vitro. However fabrication of master crowns for research purpose is hard owing to problems of precision. In 1961 Rogers explained the process of “electroforming” for the fabrication of gold matrix for a cast gold inlay and later expanded the concept to include gold copings for porcelain crowns. The electroformed coping may be fabricated to a 0.2 mm thickness with marginal gaps of less than 10 μm. Gold copings fabricated by this technique were used in this study as master crowns. The advantage of using this technique was the excellent fit of the master crown making the optimum accuracy at the margin.

To date, almost all of the studies investigating the accuracy of agar alginate combined impression method have been performed in vitro because of many difficulties in conducting an in vivo study. But it is essential to evaluate this impression method in vivo in order to substantiate its clinical application. Therefore, this study clinically evaluated the dimensional accuracy of the agar alginate combined impression and compared with other impression methods by observing the marginal accuracy of master crowns when placed on the stone dies.

Material and Methods

1. Construction of post-cores

Three patients, who had given informed consent, were included in this study. In each patient, non-vital upper right first molar indicated for crown was endodontically treated and prepared for post-core (Fig. 1). As the coronal portions of the teeth were extensively damaged, cast post-cores (M.C. type IV gold alloy, GC, Japan) were fabricated. Addition silicone impressions (Exafine, GC, Japan) were taken and working casts were made. Wax patterns (soft inlay wax, GC, Japan) with two types of margins (knife-edge and chamfer, the position of the marginal line of the core set 0.5 mm below the gingival lines) were made with a convergence angle of 12 degrees using a milling machine (F3/Ergo, Degussa Dental Co, Germany) (Fig. 2). Cast post-cores were made as usual (Fig. 3). In all three patients there were little undercut areas between the abutment teeth and adjacent teeth.

2. Fabrication of master crowns

AGC® galvano system (WIELAND, Germany) was used to make master crowns. A thin silver coating was applied over the cast cores and six master crowns (AGC® copings) of pure gold were constructed by electroforming (Ken Dentalix, Co., Ltd., Tokyo, Japan). The thickness of the frame of the master crown was 0.3 mm. These crowns fit the cast cores with a 5 to 10 μm space made by silver lacquer coating. There was no gap at the margin between the master crown and cast core. (Fig. 4)

3. Impression making

A total of ninety impressions, five impressions using each material for each of the two types of cast cores for
Fig. 2. (a) Milling of cast cores, (b) Milled knife-edge cast core.

Fig. 3. Cast cores with knife-edge (a) and chamfer, (b) Margins.

Fig. 4. (a) Cast core on the master cast, (b) Master crown on top of cast core.
Hydrocolloid Impressions:
Cast cores were fixed temporarily to the tooth using polycarboxylate temporary cement (GC, Japan). After application of a gingival retraction cord (black silk 3-0), impressions were taken using agar alginate impression material (Cartloid Dentloid, Dentoloxon and Aroma fine DFIII, GC Japan). Agar and alginate materials were prepared as recommended by the manufacturer. The tubes of agar were placed in the hydrocolloid conditioner (Mizuirasu F, Dentronics Co Ltd, Japan) and warmed for 45 minutes before use. A single cartridge of the agar impression material was syringed over the gingival margin and occlusal surface of cast cores. The alginate impression material was syringed over the gingival margin and occlusal surface of cast cores. The alginate impression material was machine mixed (Mikrona Mixer, Mikrona, Switzerland) for 10-16 seconds following manufacturer’s instructions of 8.4 g powder to 20 ml cold water (10 ± 2 °C). Impressions were poured with type IV die stone immediately and placed in a 100% humidor for 1 hour before separating.

Silicone impressions:
After placing gingival retraction cords, impressions were taken using vinylpolysiloxane impression material (Exafine, GC, Japan). Regular viscosity material was injected over the gingival margins and occlusal surfaces of cast cores. A metal impression tray with putty type material was placed over the syringed material. The impression was removed after setting with a snap motion. Impressions were placed in a 100% humidor for 1 hour before pouring and the casts were separated after 1 hour.

Silicone impressions with individual tray:
Impressions were taken using single tooth individual trays made of acrylic resin (Unifast Trad, GC, Japan) and vinylpolysiloxane impression material (Exafine, GC, Japan). A tray adhesive (GC, Japan) was applied to the inside and outside of the individual tray and left to dry for 1 minute. Regular viscosity material was injected into the individual trays and placed over the fixed cast cores. A metal impression tray with regular hard viscosity material was placed over the syringed material. The impression was removed, washed and kept for 1 hour before pouring and the casts were separated after 1 hour.

4. Fabrication of dies
Impressions were poured with type IV die stone (GC New Fujirock, GC, Japan) using a vibrator (Angel Vibrator, Daiei Dental Product Co Ltd) and following the water-powder ratio recommended by the manufacturer (20 ml water to 100 g stone). The stone was mechanically mixed under vacuum for 30 seconds (VM-1, GC, Japan) and mechanically vibrated into each impression. The casts were trimmed (Y-230, Yoshida Co, Japan), blow dried and allowed to dry for 24 hours before measuring. (Fig. 6)

5. Measurement
The master crowns were placed with slight finger pressure (0.1N) on each die produced by different impression methods. Each die, with the master crown seated in place, was observed under a micro depth and height measuring scope (Nissho Optical Co, Ltd, Japan). The gap between the margin of the master crown and the margin of the preparation on the die was measured (Fig. 7). Measurements were made in four points located at buccal, palatal, mesial and distal sides.
6. Statistical Analysis

The mean marginal gap of each die was determined by averaging three measurements of gap between the die and the master crown, for subsequent analysis. Four-way analysis of variance was carried out selecting four main factors, which were patients, shape of margin, impression methods and measured locations and their interactions. The Tukey HSD comparisons were performed when the main factor or the interaction was significant, less than 5%.

Results

All stone dies completely reproduced the edge of the preparation of cast cores. The mean marginal gaps of three patients are summarized in Table 1. The result of four-way analysis of variance (ANOVA) is shown in
Table 1. mean marginal gap (\(\mu m\)) of each patient

<table>
<thead>
<tr>
<th>Patient: 1</th>
<th>Shape of margin</th>
<th>Agar/alginlate</th>
<th>Silicone</th>
<th>Silicone with tray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knife-edge</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>Agar/alginlate</td>
<td>110.4 21.1</td>
<td>45.1 27.5</td>
<td>39.0 8.6</td>
<td></td>
</tr>
<tr>
<td>Silicone</td>
<td>32.8 21.5</td>
<td>43.3 12.8</td>
<td>37.5 14.5</td>
<td></td>
</tr>
<tr>
<td>Silicone with tray</td>
<td>36.2 26.4</td>
<td>42.5 22.7</td>
<td>36.9 14.4</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patient: 2</th>
<th>Shape of margin</th>
<th>Agar/alginlate</th>
<th>Silicone</th>
<th>Silicone with tray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knife-edge</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>Agar/alginlate</td>
<td>108.4 39.7</td>
<td>37.1 26.3</td>
<td>28.4 7.0</td>
<td></td>
</tr>
<tr>
<td>Silicone</td>
<td>36.2 26.4</td>
<td>42.5 22.7</td>
<td>36.9 14.4</td>
<td></td>
</tr>
<tr>
<td>Silicone with tray</td>
<td>39.9 19.5</td>
<td>40.2 14.3</td>
<td>38.6 11.9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patient: 3</th>
<th>Shape of margin</th>
<th>Agar/alginlate</th>
<th>Silicone</th>
<th>Silicone with tray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knife-edge</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>Agar/alginlate</td>
<td>107.7 31.9</td>
<td>42.5 18.9</td>
<td>33.5 12.0</td>
<td></td>
</tr>
<tr>
<td>Silicone</td>
<td>39.9 19.5</td>
<td>40.2 14.3</td>
<td>38.6 11.9</td>
<td></td>
</tr>
<tr>
<td>Silicone with tray</td>
<td>39.9 19.5</td>
<td>40.2 14.3</td>
<td>38.6 11.9</td>
<td></td>
</tr>
</tbody>
</table>

SD = Standard deviation

Table 2. Summary of four-way ANOVA

<table>
<thead>
<tr>
<th>Factor</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Patient</td>
<td>61</td>
<td>2</td>
<td>30.5</td>
<td>0.7</td>
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<tr>
<td>B: Impression method</td>
<td>9422</td>
<td>2</td>
<td>4711.0</td>
<td>106.0 *</td>
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<tr>
<td>C: Shape of margin</td>
<td>4629</td>
<td>1</td>
<td>4629.0</td>
<td>104.1 *</td>
</tr>
<tr>
<td>D: Location</td>
<td>58</td>
<td>3</td>
<td>19.3</td>
<td>0.4</td>
</tr>
<tr>
<td>AxB</td>
<td>54</td>
<td>4</td>
<td>13.5</td>
<td>0.3</td>
</tr>
<tr>
<td>AxC</td>
<td>87</td>
<td>2</td>
<td>43.5</td>
<td>1.0</td>
</tr>
<tr>
<td>AxD</td>
<td>465</td>
<td>6</td>
<td>77.5</td>
<td>1.7</td>
</tr>
<tr>
<td>BxC</td>
<td>11167</td>
<td>2</td>
<td>5583.5</td>
<td>125.6 *</td>
</tr>
<tr>
<td>Error</td>
<td>14582</td>
<td>328</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>40880</td>
<td>359</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.01

Discussion

The dimensional accuracy of an impression in vivo is influenced by many factors, such as soft tissue hindrance, exudates, and other difficulties in operation for intra-oral impression taking. Furthermore, there are no reference points to measure the real dimensional change between the prepared tooth and dies when an indirect technique is employed. Therefore there are few studies\(^{17}\), which evaluated the dimensional accuracy of impressions in vivo.

This study evaluated the dimensional change of the impressions by measuring the marginal gap between the master crowns and dies prepared from the impressions taken intra-orally.

Some experimental studies on evaluating accuracy of impressions using master crowns have been reported previously\(^{18}\). However they were all fabricated by casting and distortion of master crowns by casting was inevitable to a greater or lesser extent.

A technique of fabricating crowns using gold copings produced by an electroforming process was described in the past, which results in restorations with excellent fit\(^{19}\). Master crowns made by this technique were used in the present study. Constructing a master crown by electroforming results in good marginal fit. In addition, measurements can be made by marking reference points on the crown.

All the abutment teeth included for impressions were in the same position (right upper first molar), and impressions were taken by a single operator. Hence, the difference in experimental conditions between the
patients was kept minimal. Furthermore, according to the statistical analysis no significant difference was found when marginal gaps of three patients were compared.

In this study three impression methods were used for crown and bridge impression work. The results showed that the marginal gap of dies from agar alginate combined impression varied with the shape of margin. In case of agar alginate combined impression, dimensional accuracy of an impression depends on the thickness of agar material around the abutment teeth, the tear strength of the impression material when being removed from the subgingival areas and its ability to undergo elastic recovery when being removed from undercut areas. The marginal fit of the master crown on dies of agar alginate combined impressions with chamfer margin was better than those with knife-edge margin. Agar alginate impressions with chamfer margin provided comparable results with silicone impression method. But those with knife-edge margin did not provide such results. It means that in case of agar alginate impressions dimensional accuracy would be better with chamfer margin.

This could be due to the difference in bulk of agar material near the margins and around the axial walls. The chamfer margin provides more space for the agar impression material than knife-edge type, resulting in a thicker agar impression and less distortion of the impression. Laufer et al. reported similar results in their study with silicone impression materials.

However the marginal gaps did not vary with the shape of margin when silicone impression material was used in the present study. Addition silicones have good resistance to permanent deformation and are considered the most dimensionally stable impression materials. Moreover the recovery of strain is almost instantaneous and the tear resistance is adequate. As a result dies reproduced by silicone showed better fit of die regardless of tooth tray.

Conclusions

1. The agar alginate combined impression method was clinically acceptable with chamfer margin but the shape of the margin may affect the accuracy of dies.
2. The shape of the margin did not affect the accuracy when silicone impression material, with or without individual tooth tray, is used.
3. Master crowns made by electroforming technique could be useful for clinical evaluation of impression methods.

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References