Effect of the Association Between the Tray and Impression Techniques on Angulated Implants Using the All-on-Four System

Erica Dorigatti de Avila*
Sabrina Maria Castanharo
Nicole Casalle
Juliano Alencar Vasconcelos
Francisco de Assis Mollo, Jr

INTRODUCTION

The impression represents a critical clinical stage to obtaining an accurate three-dimensional representation of the intraoral relationship between implants, teeth, and adjacent structures. Any inaccuracy during the impression stage will result in a lack of fit and misfit of the prosthesis, especially in implant-supported prostheses. In 1993, Barret et al verified that obtaining an accurate model for rehabilitation with implants depends on the type of impression material, the technique, the tray, and the number and position of the implants. In 2010, Sorrentino et al noted that impressions performed with angled implants exhibited lower accuracy than those made with parallel implants. Impression materials, with the addition of silicone, facilitated the creation of accurate impressions of parallel implants. In contrast, polyether exhibited better results with parallel implants. The authors concluded that the angulation of the implants could cause tension within the impressions, most likely due to the greater forces necessary to remove the molds from the stone cast. Furthermore, nonparallel implants negatively affect the accuracy of casts as well as the type of tray. The open tray allows for the copings to remain in the impression, reducing the deformation of the impression material and, consequently, the effect on the implant angulation. Few studies have been conducted to assess which could interfere in the final accuracy of impression in case of nonparallel implants on the final accuracy of the impression. Therefore, the aim of this study was to analyze the effect of the association among trays, impression technique, and the type of stone with angled implants under standardized laboratory conditions. The null hypothesis was that there would be no difference among the groups.

MATERIALS AND METHODS

The metallic aluminum matrices were made from designs developed in AutoCAD with four perforations (“All-on-Four” system). In the perforations were fixed analogs (Micro Unit, Conexão, São Paulo, Brazil) called A, B, C and D, two anterior parallel implants (BC), and two mesial-distal angled implants (AD). The master cast offers an integrated system of impression and shaping without the transmission of forces to materials used in the process due to an infinity system of threads and latches (Figure 1). A framework was fabricated with titanium cylinders and 2-mm-diameter cylindric titanium bars (Conexão, Conexão Prosthesis Systems) and served as the standard for the assessment of all subsequent measurements in determining the accuracy of casts made from different transfer procedures. We formed 6 experimental groups, and the gaps values between the framework and the experimental casts were compared with the gap between the framework and the analogues of the CAD/CAM matrices:

G1: Fujirock Plaster + impression with Matrix CAD/CAM (n = 7)
G2: Durone Plaster + impression with Matrix CAD/CAM (n = 7)
G3: Impression with metallic tray (Giachetti BABY-P39 aluminum) (n = 7)
S: Impression technique with squared, nonsplinted copings
SS: Impression technique with squared, splinted copings using metal drill burs and Pattern resin.

Groups G1-S, G2-S, and G3-S: The squared copings were screwed with the digital key on the external 1.17-mm hexagon until resistance was felt, and a torque of 10 Ncm was then used to tighten them.

Groups G1-SS, G2-SS and G3-SS: The squared copings were fixed on a metallic circular cutting device, 1.5 mm in diameter, with cyanoacrylate adhesive (shear strength of 100 kgf/cm²). They were reinforced with acrylic pattern resin using a bead-brush technique to ensure security.

All the impressions were created in a temperature-controlled environment (23°C ± 2°C) with a relative humidity of 50% ± 10%. Polyvinyl siloxane impression material (Express putty/light body, 3M ESPE) was used for all impressions. The impressions were made by keeping the tray in its full-lock position for 10 minutes, until polymerization was complete (Figures 2 and 3). The setting time according to the manufacturer was doubled to compensate for the delay of polymerization. The screws of the copings were unscrewed,
and the tray or matrix/cast were separated. In the mold, the analogs were screwed with a torque of 10 Ncm. After 60 minutes, type IV dental stone was poured with constant vibration. The bolts were unscrewed, and the tray/cast were separated, thus obtaining replicas (Figures 4 and 5).

Taking the plaster casts and after approximately 60 hours of production on the samples, the metallic framework was bolted on analogs, and the gaps between the framework and the analogs were analyzed.

A framework was screwed on each cast, and a titanium screw was tightened on analog A to keep the framework in position (Figure 6). Then, 10 Ncm was applied with a torque driver, after which the gaps formed in analogs C and D were measured. This procedure was repeated for analog D, observing the measurements for analogs A and B. For the measurements, software (Leica QWin, Leica Imaging Systems, Cambridge, UK) received the images from a video camera (JVC, 0.5 inches CCD, model TK-C1380, Tokyo, Japan) coupled to a Leica stereomicroscope (Leica Microsystems, Wetzlar, Germany) at ×100 magnification. Marks were made at the center of each titanium abutment to standardize the area for image capture. For each image obtained, linear readings of the gaps were made in three areas, and the mean of these three values was considered to represent the gap (Figure 7). To standardize the positioning of the casts, a device was fabricated in which all the plaster casts were provided with a film-magnet to stabilize the bottom surface near a metal plate (Figure 8a and b). The same blinded examiner collected all the measurements. The extensions of the gaps were evaluated using an analysis of variance with two main factors—mode molding (group) and transfer method—and a repeated measures factor, which measured the cracks in the analog. The control group consisted of isolated master casts. This analysis was complemented by multiple comparisons of means using Tukey’s test. We adopted a significance level of 5% for decisions.

**RESULTS**

Table 1 shows the means and standard of gaps extensions (in microns) of all groups. The variance analyzes of repeated measures indicated significance effect of interaction among all
The results of multiple comparisons of means for each analogue are summarized in Table 2. There are significant differences between means only in analogs A and C. While in any analog A, the mean was significantly different from control at analog C, only the average of G2-S was higher than the control.

This same analysis did not present significance effect neither among the analogues and tray/impression techniques, either among the interaction of all factors (\( P > 0.05 \)). So, this result holds for the group averages of the 4 analogues by their averages, as shown in Table 1. The average of the 2 methods are actually very close, but there still has been no statistical differences; we note that trends in global averages of G2 and G3 are close and larger than the average control. The G1, in turn, presented the next medium control.

**DISCUSSION**

Based on the results of this study, the null hypothesis that the type of tray would not influence the results with different impression techniques with angled implants was accepted.

In relation to the variation of impression techniques, the goal of splinting the copings was to prevent movement and consequently reduce dimensional changes generated by the impression material. However, the results showed no statistically significant difference among the impression techniques for all groups: MC = 68.0, G1S = 67.5, G1SS = 65.6, G2S = 79.1, G2SS = 78.2, G3S = 74.3, and G3SS = 73.2. This is contrary to the scientific literature, which showed that there were differences among the groups when the split of the coping is performed.13–16 In a recent study, we compared two impression techniques, in one group with rigid split among the coping and, in another group, no split. In that study, we observed a statistically significant difference between techniques with lower gaps values when the copings were splinted with bar and acrylic resin.15 In the same year, Ongü et al compared the accuracy of two impression techniques using bars of acrylic resin and bars of light-cured composite resin, and the authors concluded that the impressions exhibited superior results for various implants splinted among copings with rigid material compared to other techniques.17

With regard to the variation of the type of tray, although having lower numerical values when the CAD/CAM array was used, there was no statistically significant difference between the matrix and metal tray groups (\( P = 0.99 \)). In the case of a device that allows for a patterned impression due to the stabilization of the whole matrix/model equalized for all samples, we believed that the value of the gaps should have been lower compared to the master model. However, these results can be explained because similar to the CAD/CAM matrix, the metal tray is rigid and resists deformation during the use of a polyvinyl siloxane impression material with a putty consistency.18,19 The stability of both matrix and metal tray did not allow any movement of the nonsplinted copings. In the

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**Table 1**

<table>
<thead>
<tr>
<th>Group</th>
<th>Technique</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Overall</th>
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<tbody>
<tr>
<td>Master cast</td>
<td></td>
<td>88.8ab</td>
<td>56.8*</td>
<td>61.3*</td>
<td>65.0a</td>
<td>68.0*</td>
</tr>
<tr>
<td></td>
<td>SD</td>
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<td>17.5</td>
<td>16.9</td>
<td>19.6</td>
<td>8.6</td>
</tr>
<tr>
<td>G1</td>
<td>S</td>
<td>69.5a</td>
<td>65.3*</td>
<td>76.3ab</td>
<td>58.6a</td>
<td>67.5*</td>
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<tr>
<td></td>
<td>SD</td>
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<td>28.7</td>
<td>39.2</td>
<td>13.0</td>
<td>18.0</td>
</tr>
<tr>
<td>G2</td>
<td>S</td>
<td>80.8ab</td>
<td>55.6*</td>
<td>49.1*</td>
<td>77.1a</td>
<td>65.6*</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>12.4</td>
<td>33.3</td>
<td>40.7</td>
<td>26.1</td>
<td>25.1</td>
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<tr>
<td>SS</td>
<td>S</td>
<td>90.1ab</td>
<td>72.4a</td>
<td>69.6ab</td>
<td>80.6a</td>
<td>78.2*</td>
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<tr>
<td></td>
<td>SD</td>
<td>9.8</td>
<td>22.4</td>
<td>28.8</td>
<td>11.0</td>
<td>11.5</td>
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<tr>
<td>G3</td>
<td>S</td>
<td>117.8b</td>
<td>60.1a</td>
<td>38.9a</td>
<td>80.3a</td>
<td>74.3*</td>
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<tr>
<td></td>
<td>SD</td>
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<td>21.2</td>
<td>18.4</td>
<td>13.2</td>
<td>15.3</td>
</tr>
<tr>
<td>SS</td>
<td>S</td>
<td>103.5ab</td>
<td>49.1*</td>
<td>59.7a</td>
<td>80.5a</td>
<td>73.2*</td>
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<tr>
<td></td>
<td>SD</td>
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<td>10.2</td>
<td>32.4</td>
<td>21.1</td>
<td>12.9</td>
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</tbody>
</table>

*Means in columns followed by the same letter are not significantly different from the Tukey test (\( P > 0.05 \)).

**Table 2**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Degrees of freedom</th>
<th>Quadratic mean</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>2</td>
<td>2060.6</td>
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<td>0.125</td>
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<td>Techniques</td>
<td>1</td>
<td>67.7</td>
<td>0.072</td>
<td>0.790</td>
</tr>
<tr>
<td>Groups × Technique</td>
<td>2</td>
<td>3.6</td>
<td>0.004</td>
<td>0.996</td>
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<tr>
<td>Residue†</td>
<td>42</td>
<td>942.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog</td>
<td>3</td>
<td>6377.5</td>
<td>18.545</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Analog × Group</td>
<td>6</td>
<td>3902.7</td>
<td>11.349</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Analog × Technique</td>
<td>3</td>
<td>1965.2</td>
<td>5.715</td>
<td>0.001*</td>
</tr>
<tr>
<td>Residue‡</td>
<td>126</td>
<td>343.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

†The results of multiple comparisons of means by the Tukey test is summarized in Table 1.

‡Grouping the extensions of similar gaps; no significant effect of group or method of interaction between them.
groups in which the CAD/CAM matrix was used as the tray, the type of plaster also varied. This current study used a direct technique with open-tray and squared coping. Although the scientific literature is contradictory in relation to the type of tray and implants position,1,3,7,20–22 the studies that found no difference between the close-tray technique and angled implants, used different angulation and number of implants, and different devices for evaluation.1,20–22 Moreover, it should be emphasized that these studies were performed in vitro; however, in clinical situations, the results could be different. In vitro studies, it is possible to control all variables and standardize all procedures stages without any type of interference related to the patient, such as nausea, tongue, and saliva.

The use of two types of plasters for the array groups may be justified because it is an accurate impression device that may draw speculation on the different characteristics of plaster in the event of differences in the gap values. However, varying the type of plaster did not yield differences in the values of the gaps: G1 = 67.5, G2 = 79.1.

For all groups, the gaps values formed between the metallic framework and implants were within the limits established by science (111 mm).6

**ABBREVIATION**

CAD/CAM: computer-aided design/computer-aided machining

**ACKNOWLEDGMENT**

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**REFERENCES**