Effect of Splinting in Accuracy of Two Implant Impression Techniques

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Because there is no consensus in the literature about the need for a splint between copings, the aim of this study was to evaluate, in vitro, the accuracy of 2 impression techniques for implant-supported prostheses. A master cast was fabricated with four parallel implant abutment analogs and a passive framework. Two groups with 5 casts each were formed: Group 1 (squared impression copings with no splint: S) and Group 2 (splinted squared impression copings, using metal drill burs and Pattern resin: SS). The impression material used was polyvinyl siloxane with open trays for standard preparation of the casts. For each cast, the framework was positioned, and a titanium screw was tightened with 10 N-cm torque in analog A, after which measurements of the abutment-framework interface gaps were performed at analogs C and D. This process was repeated for analog D. These measurements were analyzed using software. A one-way analysis of variance (ANOVA) with a confidence interval of 95% was used to analyze the data. Significant differences were detected between S and SS in relation to the master cast ($P \leq 0.05$). The median values of the abutment-framework interface gaps were as follows: master cast: 39.64 μm; squared impression copings with no splint: 205.86 μm; splinted squared impression copings: 99.19 μm. Under the limitations of this study, the technique presented for Group 2 produces better results compared with the technique used for Group 1.

Key Words: dental implants, impression techniques, splinting material, dental material, impression materials

INTRODUCTION

The accuracy of the transfer of the implant positions to the final cast is the determining factor for the success of total or partial rehabilitation with implant-supported prostheses, as the prosthesis and the framework will be created using this cast.1 Over the past decades, many abutments—such as the UCLA abutment and the DIA anatomic abutment—were introduced to resolve complications. However, problems remained with improper fit, imprecise adaptation, and unfavorable anti-rotational capacity.2 These mechanical complications could lead to the loss of the screws, screw fracture, implant fracture and disequilibrium of the occlusion.

With the recent development of computer-aided design/computer-aided manufacturing technology, custom abutments are gradually coming into use in certain systems of dental implants. This new system fascinated professionals with the possibility of the fabrication of prosthesis components around dental implants with extreme accuracy. However, these techniques are based on the digitalization of a cast produced through conventional steps.3 The computer-aided design system has the capacity for the three-dimensional evaluation, through scanner tone detection of the surface of a dental stone cast,
allowing the detection of discrepancies between the original preparation and the replica. This system will evaluate the accuracy of a digitalized stone replica and will describe the efficiency of the impression technique, the material used, and the stone cast fabricated. For this reason, the literature recommends the digitalization of the site of interest only after a correct impression and the fabrication of a master cast that is faithful to the original structure.\(^4\)\(^,\)\(^5\) Technological advancement justifies the continuous search for the passivity of fit of the prosthetic components.

In contrast, the precise transfer of the implants depends on the tray type,\(^6\) impression material and impression techniques used. Although several studies have been performed in an attempt to evaluate the impact of the impression techniques and the different dental materials on the accuracy of prosthetic components and dental implants, the literature is still sparse about which impression techniques are superior and whether the time used to splint the copings would be compensated with significant benefits.\(^7\) This study aimed to compare two impression techniques in a standard environment and tested the null hypothesis, which is that there would be no differences between the groups.

**METHODS**

This experimental study in vitro has two independent quantitative variables.

A brass mandibular edentulous cast was fabricated to serve as a master cast (Figure 1). Four dental implant abutment analogs were inserted, in parallel, into this mandible, simulating a clinical situation using the Branemark protocol (Micro-Unit; Conexão Sistema de Prótese, São Paulo, Brazil) (Figure 2). After the welding of the master model, the original analogs were removed, and new analogs were inserted with the aid of a calibrated torque wrench (Conexão, Conexão System of Prostheses) limited to 10 N-cm (Figure 3). The new analogs were incorporated into the master cast with epoxy resin (Araldite Professional 24 horas Vantico, Taboão da Serra, SP, Brazil) to avoid rotational movement. Five circular depressions that were 6 mm wide and 3 mm deep were created around the cast to standardize the positioning of the tray. The implant analogs were denominated A, B, C, and D based on a frontal view of the master cast.

Next, a framework with a passive fitting was fabricated around the new analogs (Figure 4). The framework was made using titanium cylinders and 2-mm-diameter titanium bars (Conexão, Conexão Sistema de Prótese) (Figure 5). The framework was used as a standard to evaluate its adaptation around all of the stone casts, thus comparing the results of the 2 impression techniques.

The matrix for pouring the impression with dental stone was made with condensation silicone (Zetaplus/Oranwash, Zhermack, Badia Polesine, Italy) for all of the impressions, allowing the standardization of the format of the casts and the amount of dental stone employed for the pouring.

A pilot study was performed to define the sample size. First, the \(n\) of the sample used in this pilot study was based on the scientific literature. Based on the distribution of these results and the standard deviation—and considering, at the same time, the confidence interval of 95% and the sample error—the required sample size was defined. In a second step, the groups were formed, and the methods established.

Two groups with five casts each were evaluated:

**Group 1.** Impression technique with squared, non-splinted copings (S). The squared copings were positioned on analogs, and a torque of 10 N-cm was used to tighten them (Figure 6).

**Group 2.** Impression technique with squared, splinted copings using metal drill burs and Pattern resin (SS). The shanks of right-angle burs (2.35 mm in diameter) were fixed with cyanoacrylate adhesive in the square impression copings. Small amounts of Pattern Resin were added incrementally to the shanks of the right-angle burs and impression copings, using a bead-brush technique to ensure security. For Group 2, the squared copings were positioned on analogs, and the screw was tightened by 10 N-cm using a torque driver. The metal drill burs were then fixed on the squared copings with Pattern Resin. For the procedure, the distance between the copings was determined to certify the length of the drill burs. The metal drill burs were cut with diamond burs at high speed. A drop of cyanoacrylate was placed on the ends of the drill burs to enable the placement of a host bar in the correct location with respect to the copings. Subsequently, the Pattern Resin was applied in
increments over the square coping area and the part of the drill (Figure 7).

All of the impressions were made in a temperature-controlled environment (23°C ± 2°C) with a relative humidity of 50% ± 10%. The impression material polyvinyl siloxane (Express putty/light body, 3M ESPE, St Paul, Minn) was used according to the manufacturer’s instructions. The putty impression material was manipulated for 30 seconds and was placed on a size 4 stock tray. The manufacturer’s setting time was doubled to compensate for a delayed polymerization reaction at

**Figures 1–6.**

**Figure 1.** Brass master cast. **Figure 2.** Positioning of the analogs with the aid of a surveyor. **Figure 3.** Analogos positioned in master cast. **Figure 4.** Master cast and metal framework. **Figure 5.** Bar composed of four cylinders titanium. **Figure 6.** Non-splinted impression technique.
room temperature rather than at mouth temperature. Simultaneously, the lightweight material was injected around the copings and the tray positioned on the master. A weight of 1.25 kg was placed on the tray for 10 minutes to standardize the output of the excess material. After 30 minutes, the screws were removed, and the set tray/matrix were separated from the master model. Then, new analogs were positioned on the cast and fixed with screws with a torque of 10 N·cm. A hemostatic pincer was used to prevent the rotational movement of the analogs during the torque (Figure 8).

All of the molds of each impression were poured with dental stone type IV (Durone). A proportion of 22 mL of water to 110 g of stone was used. First, the stone was mixed manually with water for 15 seconds to aid the incorporation of the water. The mixing was completed mechanically under a vacuum for 30 seconds with a digital vacuum spatulator (Turbomix EDG Equipment). All of the stone mixes were vibrated before and during the pouring. The stone casts remained on the mold for 2 hours before the separation. All 10 casts were stored at room temperature for 15 days before the measurements.

The four analogs of the master cast were denominated sequentially as A–D, from left to right (Figure 9). The framework was positioned on each cast, and a titanium screw was tightened on analog A by 10 N·cm using a torque driver, after which the gaps formed in analogs C and D were measured. This procedure was repeated for analog D, noting the measurements for analogs A and B.

The measurements were analyzed with software (Leica QWin; Leica Imaging Systems) that 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), ×100 magnification. Marks were made in 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 10).

All of the measurements were recorded by the same blinded examiner. To verify the intra-examiner reliability, that is, the calibration of the examiner, one person analyzed the same images on 2 different occasions, with an interval of 2
weeks between the first and second assessment. The reproducibility of the results was then evaluated by calculating the correlation coefficients and confidence interval of 95% at 2 different times. With the aid of SigmaStat version 3.11 (Systat, Evanston, Ill), an appropriate statistical test was applied. Because the data exhibited a non-normal distribution with unequal variances, a Kruskal-Wallis one-way analysis of variance (ANOVA) was used. The level of statistical significance was set at $P \leq 0.05$.

**RESULTS**

Two groups were formed with 5 casts each, for a total of 10 casts. Forty gap values were calculated. The mean gap value for the master cast was 39.64 $\mu$m. The mean and median values of the abutment-framework interface gaps are shown in Table 1. The data were analyzed for a normal distribution with the Kolmogorov-Smirnov test (normality test). An analysis of variance used to compare the slopes by four F-tests found significant differences between the slopes. A test of nonparametric data was used to determine statistical discrepancies between Groups 1 (non-splints vs control) and 2 (splints vs control). Significant differences were detected between S and SS in relation to the master cast ($P < 0.05$). The values of the Kruskal-Wallis one-way ANOVA are summarized in Table 2.

**DISCUSSION**

The more accurate impression technique was the impression technique with squared splinted copings with metal drill burs and Pattern Resin; thus, the null hypothesis of the present study was rejected. Significant differences were detected between the splinted and non-splinted techniques. The control group (master cast) presented a gap of 39.64 $\mu$m, determined by the distance between the framework and the analog. Because the biological tolerance for the misfit among prosthesis components is approximately 111 $\mu$m, the gap values obtained in the present study are considered to be admissible.11

The passive fit of an implant-supported prosthesis is known to be directly dependent on the accuracy of the impression technique. Several studies have evaluated the accuracy of the impression, measuring the distances between the gaps and comparing with the control group. However, many variables are observed, such as the impression material, impression technique, type of stone, time and method of manipulation, type of tray used, mandible or maxilla, disposition of the implants and the master cast that simulates the edentulous arch.12,13 In this study, the master cast represented an edentulous mandible with implants parallel to and equidistant from each other, simulating a clinical situation of the Branemark protocol.

The main aim of the impression of multiple implants is to record and transfer the relationship between the implants’ abutments or prostheses and reproduce these relations with greater precision in a stone cast. Toward this end, the scientific literature presents 3 types of impression techniques: the indirect impression technique, the direct impression technique, and the splinted direct impression technique. The first technique is performed with tapered copings, whereas in the direct techniques, the squared copings are removed with the tray.14 The literature presents the use of the indirect technique to patients suffering from nausea, as the results show lower values compared with the direct technique.15-17 At this time, several techniques to splint copings and improve the accuracy of adaptation between them have been suggested. Among these techniques are the uses of

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**Table 1**

<table>
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<tr>
<th></th>
<th>Squared non-splinted impression transfers technique</th>
<th>Squared splinted impression transfers technique</th>
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<tbody>
<tr>
<td>Master cast</td>
<td>Mean 40.52</td>
<td>Median 39.64</td>
</tr>
<tr>
<td></td>
<td>Mean 213.30</td>
<td>Median 205.86</td>
</tr>
<tr>
<td></td>
<td>Median 115.00</td>
<td>Median 99.19</td>
</tr>
</tbody>
</table>

**Table 2**

Kruskal-Wallis test used to compare the two techniques with the master cast*

<table>
<thead>
<tr>
<th>Group</th>
<th>Median</th>
<th>25%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master cast</td>
<td>39.64</td>
<td>13.15</td>
<td>62.04</td>
</tr>
<tr>
<td>S</td>
<td>205.86</td>
<td>178.66</td>
<td>258.31</td>
</tr>
<tr>
<td>SS</td>
<td>99.19</td>
<td>80.71</td>
<td>155.91</td>
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*H = 42.049 with 2 degrees of freedom ($P \leq 0.001$).
splints with acrylic resin using dental floss, bars prefabricated from acrylic resin, stainless steel bars, and orthodontic wires.\textsuperscript{13,18}

With so many variables in an in vitro study, it is necessary to standardize the materials and methods and the experimental environment and to verify the calibration of the examiner responsible for the measurements to allow a meaningful comparison with other works. Previous in vitro studies have compared the impression techniques using squared splinted and non-splinted copings and have obtained inconsistent results.\textsuperscript{14,16,19–21} Nevertheless, the results of this study are in agreement with most in vitro studies on edentulous jaws,\textsuperscript{17,21} and the differences occur in the type of splinting among the copings and the methods used for the analysis of the gaps. Papaspyridakos et al\textsuperscript{21} compared the dimensional accuracy of two impression techniques, splinted and non-splinted, with a master cast (control group). These copings were splinted with acrylic resin. After polymerization, the splinting was sectioned and united again with the same material. This procedure would reduce the contraction of the first resin polymerization. The authors concluded that the impression technique in which the copings were splinted produced more accurate casts, similar to the results of our study, considering a 95% confidence interval.\textsuperscript{21} However, because of differences in the distributions of the results, parametric and nonparametric, and the differences in the sample sizes, there is no way to guarantee that there are no inconsistencies between the results of these 2 studies.

The aim of the splinting technique is to stabilize the copings during the impression, to prevent movement and, consequently, to reduce the dimensional changes generated by the impression material in making the cast. Similarly, the ideal impression technique should involve certain characteristics, such as minimum time, ease of use, low cost, comfort for the patient, and production of accurate casts. Although the direct splinting technique does not offer all of these features, the best results, according to the literature, justify the application in clinical practice. The splints performed with metal drill burs, specifically, would yield better results because of the rigidity of that material and, consequently, would not suffer contraction or expansion, in contrast to resins. This statement agrees with the work of Del’Acqua et al.\textsuperscript{22} These authors compare the dimensional accuracy of 2 impression techniques, both splinting copings: Duralay resin, and metal drill burs and Pattern Resin. The results revealed statistically significant differences between the groups Duralay resin 165 m / Pattern Resin 69 m, and among these groups and the master cast (32 m). It is important to consider that this work was performed using the same laboratory standards as the research in question, differing only in the brand of the stone used. Consistent with our study, Del’Acqua and colleagues’ Group M yielded better results than the other groups.\textsuperscript{22} However, the median value obtained in our work appears to be statistically different from the median of Del’Acqua et al. Because that study maintained the laboratory standards for fabricating casts, it is suggested that, despite the pilot study, an increase in sample size could better define these results.\textsuperscript{22}

Stimmelmayer et al\textsuperscript{18} also obtained better results for the splinted impression technique compared with non-splinted impression techniques. At the same time, the values presented in this study [80 (± 25) M] are similar, statistically, to our results (99.19 m). However, in their impression technique—although it was direct and splinted—the form of the splints between the copings was produced with acrylic resin. This result agrees with other studies and suggests that the splinted direct impression technique with acrylic resin is more accurate.\textsuperscript{14,20} The splinted direct impression technique allows professionals to select the type of splinting that matches the ability of the individual at the time of manufacture.

**Conclusion**

Under the limitations of this study, it is possible to draw the following conclusions: the impression technique influences the accuracy of the fit between the prosthesis components; both impression techniques are statistically different compared with the master cast, and the SS impression technique yielded more accurate results than the S technique.

**Abbreviations**

S: squared, non-splinted copings
SS: squared, splinted copings using metal drill burs and Pattern resin

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