Accuracy of Impression Techniques with Maxillary Angled Implants Using Trays and Multifunctional Guides

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**Purpose:** The purpose of this study was to evaluate in vitro the accuracy of different splinting techniques using transfers combined with different tray types. **Materials and Methods:** The research group fabricated a maxillary master cast with four implants and a passive metallic bar on this master cast. For the impression techniques, 48 casts were used with six different impression techniques: (1) metal tray with resin splinted transfers, (2) metal tray with metal and resin splinted transfers, (3) plastic tray with resin splinted transfers, (4) plastic tray with metal and resin splinted transfers, (5) multifunctional guide with resin splinted transfers, and (6) multifunctional guide with metal and resin splinted transfers (n = 8) using polyvinyl siloxane impression material. This study used a passive metallic bar to measure the malalignment between the framework and the analogs (A, B, C, and D) in 2D and 3D. The master and experimental casts were scanned with a contact scanner to compare the accuracy in 3D impression techniques. Discrepancies between the analogs were measured in three x-, y-, and z-axes. **Results:** There was no statistically significant difference (P > .05) between the groups in vertical malalignments (2D). In the 3D evaluation, for the z-axis and combination of xz-axis, plastic tray with metal, and resin splinted transfers (z = 487 μm; xz = 888 μm), there was a statistically significant difference compared with the multifunctional guide and resin splinted transfers (z = 772 μm; xz = 1,380 μm). When analyzing by analog, in C, the multifunctional guide with metal and resin splinted transfers (302 μm) presented a statistically significant difference compared with the multifunctional guide and resin splinted transfers (492 μm). **Conclusion:** The evaluation methods for the accuracy impression technique presented different results between them. There was no difference in vertical malalignments (2D), but in 3D, the bonding with metal and acrylic resin presented better results than the bond with only acrylic resin when using the plastic tray and multifunctional guide, respectively, in the z-axis and the combination between the xz-axes. The bonding technique of the transfers with metal and acrylic resin presents better results in the 3D analysis for the multifunctional guide impressions. Int J Oral Maxillofac Implants 2021;36:530–537. doi: 10.11607/jomi.7921

**Keywords:** dental implant, dental materials, dental prosthesis

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Implant-supported fixed complete denture rehabilitation supported by four implants with immediate loading for fixed acrylic prostheses in the maxilla is an efficient treatment option in edentulous patients.1 Some studies have shown no significant differences in the distribution of forces when four or five implants are used. The inclination of the posterior implants improves the distribution of forces regardless of the number of implants used.1–3 Inclined implants are used in this type of prosthesis to reduce the horizontal extension of cantilevers and/or avoid grafting surgeries of the maxillary sinus, bringing as an additional advantage a better distribution of implants in unfavorable cases.4,5

However, passive settlement of fixed prostheses is a crucial success factor. Therefore, precise impression is essential for the clinical success of rehabilitation treatment.6,7 because, unlike the dentures in natural teeth, the implants, due to the absence of periodontal ligament, will transmit directly to the peri-implant tissues, both the intrinsic tension of the prosthesis and the physiologic tension, making the success of the osseointegration depend on the way the mechanical stresses are transferred from the implants to the bone.7–9

To achieve the best passive settling, it is essential to accurately perform the transfer of the implant’s 3D position from the mouth to the cast. However, the accuracy of transfer impression is influenced by several factors, such as bonding of mold transfers, implant angulation,
number of implants, distortion of impression material, dimensional change of plaster, and the design and rigidity of the mold.\textsuperscript{7,10} Among these factors that may influence the precision of the impression, the bonding of the transfers seems to be the most significant factor, especially in the cases of four or more implants. During bonding, the distortion of the material used in the bonding and/or breaking of the bond between the bonding material and the transfer can adversely affect the accuracy of the impression. Further, the shrinkage of polymerization of the acrylic resin used in the bonding may decrease the precision of the impression.\textsuperscript{10}

The most common tray types currently used for implant-supported fixed complete denture impressions are metallic, plastic, and the multifunctional guide (individual tray). Several studies recommend the use of rigid trays, regardless of the impression material used.\textsuperscript{11,12} Conversely, individual trays (such as the multifunctional guide) can produce more accurate casts using less impression material. However, few studies compared how the molds can influence the accuracy of an implant-supported fixed complete denture impression.\textsuperscript{11–13}

Thus, due to the importance of achieving passivity in the success of an implant-supported fixed complete denture rehabilitation, there is the possibility of using an angled abutment, which can interfere in the obtaining of precise casts, and the type of bonding and tray can affect the precision of the mold. The purpose of the present study was to evaluate in vitro the accuracy of casts simulating an implant-supported fixed complete denture rehabilitation supported by four implants in the maxilla obtained from different tray types (prototyped multifunctional guide, plastic, and metal trays) and two bonding techniques of the square impression copings (metallic rods with acrylic resin, and only with acrylic resin) through the evaluation of vertical mal-alignment (2D) and 3D overlap evaluation using digital images from scanning.

**MATERIALS AND METHODS**

Four external hexagon implants were placed with a regular platform (Conexão) in a maxilla metallic cast. Two implants in the premaxilla region were parallel to each other, and two implants with a 45-degree inclination were in the posterior region to the canine fossa. Abutments (Micro-Unit) were placed over implants on the anterior and posterior region of the maxilla, with a 3-mm transmucosal height (Conexão). The posterior used angled intermediates at 30 degrees, as the master cast of the study. A passive metallic bar was made on this master cast, simulating a metallic infrastructure for an implant-supported fixed complete denture (Fig 1).

**Sample Group**

The six experimental groups of the present study were divided according to the tray (metal and plastic) and splinted transfers used (only acrylic resin or metal with acrylic resin): (1) metal tray and resin splinted transfers, (2) metal tray with metal and resin splinted transfers, (3) plastic tray and resin splinted transfers, (4) plastic tray with metal and resin splinted transfers, (5) multifunctional guide and resin splinted transfers, and (6) multifunctional guide with metal and resin splinted transfers (Table 1).

**Bonding Techniques**

Square impression copings (transfer) were used with two different bonding techniques:

- Only acrylic resin (Pattern Resin, GC America)
- Metal bars and acrylic resin (Pattern Resin, GC America)

All the square impression copings were placed on the abutments using 10-Ncm torque for standardization. The acrylic resin was initially applied around the retentive portion of square impression copings, where the bonding technique used only the resin (Pattern Resin, GC America). The previously fabricated acrylic resin cylinders were sectioned into appropriate lengths to close the adjacent space.

![Fig 1](image-url) The master cast with a passive metallic bar.

<table>
<thead>
<tr>
<th>Type of impression</th>
<th>Bonding techniques for transfers</th>
<th>Group name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifunctional guide</td>
<td>Metal and resin</td>
<td>GMM</td>
</tr>
<tr>
<td>Multifunctional guide</td>
<td>Resin</td>
<td>GMR</td>
</tr>
<tr>
<td>Plastic tray</td>
<td>Metal and resin</td>
<td>MPM</td>
</tr>
<tr>
<td>Plastic tray</td>
<td>Resin</td>
<td>MPR</td>
</tr>
<tr>
<td>Metallic tray</td>
<td>Metal and resin</td>
<td>MMM</td>
</tr>
<tr>
<td>Metallic tray</td>
<td>Resin</td>
<td>MMR</td>
</tr>
</tbody>
</table>
The resin cylinder boundaries, using the brushing technique, were attached to the square impression copings. A resin polymerization period of at least 17 minutes before its sectioning and rebonding was expected\(^\text{14,15}\). Although Ivanhoe et al\(^\text{16}\) left 1 mm of space between each transfer, only the space created by cutting the resin cylinder with a double-sided diamond disk was standardized. It is possible to minimize tensions produced by resin contraction (De La Cruz et al\(^\text{17}\)). After the cut, the cylinders were rebonded with acrylic resin, and another 17 minutes were expected for the impression.\(^\text{14,15}\) The square impression copings were also attached to the guide with acrylic resin in the multifunctional guide impression.

For the bonding method using metal bars and acrylic resin, square impression copings were initially bonded together with 2.3-mm-diameter stainless steel cylinders (simulating chip fragments) with cyanoacrylate (SuperBonder, Loctite). Later, this bond was reinforced with acrylic resin (Pattern Resin) by the brush technique, and it took 17 minutes for the impression.\(^\text{14,15}\) The square impression copings were also attached to the guide with acrylic resin in the multifunctional guide impression.

### Conventional Impression

The impressions were performed with the polyvinyl siloxane Express XT (3M ESPE), in putty and regular consistencies using three different tray types: No. 06 plastic trays (Dental Morelli), 54 perforated metal trays (Moldeiras Tecnodent Indústria & Comércio), and a multifunctional guide.

In the impressions made with stock trays (metallic and plastic), perforations in the implant regions were made to pass through the screw of the square impression copings, allowing access after the impression. However, the multifunctional guides used as trays were virtually designed from the cast after the scanning using a contact scanner (MDX-40, Roland, CTI) calibrated at 0.2 mm for each stroke of the contact tip on the scanned surface. The *.STL image file was exported to the Bio-CAD program (Computer Assisted Design, Rhino3D, Rhinoceros), serving as a mesh for the virtual drawing of the multipurpose guide with a standard thickness of 2.5 mm, simulating the conformation of a multifunctional guide used clinically. This guide was made after the virtual drawing in an additive machine that works with Polyjet technology (Stratasys brand, model Objet350 Connex). The equipment works with photopolymerizable resins deposited by multiple injector heads.

With all the trays adjusted, the impressions used putty polyvinyl siloxane (a portion of each polyvinyl siloxane was weighed to use the same amount of material in all impressions) and handled following the manufacturer's specifications. The regular polyvinyl siloxane was handled in a self-mixing tip coupled with the manufacturer’s dispenser (the amount of regular material used was also standardized for all impressions, using two clicks of the dispenser for each impression). The first 3.0 cm of this mixture was dispensed, guaranteeing the homogeneity of the material. Due to the polyvinyl siloxane's incompatibility with the latex,\(^\text{14}\) the putty polyvinyl siloxane was manually handled by a sole operator (L.P.O.) wearing vinyl gloves.

In the multifunctional guide impression, the regular polyvinyl siloxane was injected into the interest region (around the transfers attached to the multifunctional guide). Simultaneously, the dense material was inserted onto the regular material with a slight digital pressure to adjust the material to the multifunctional guide. In the impression with stock trays, the light material was also injected around the transfers, and the putty material was placed in the tray to carry out the impression. After the impression, a 1-kg mass was placed on the guide to standardize the pressure of all the molds. After 2 hours, the screws of square impression copings were removed, and the mold was pulled up and analyzed to identify any bubbles or flaws in the molding. A new molding was performed in case of its presence; otherwise, it was continued with the experimental gypsum cast production process.

### Experimental Cast Production

After 2 hours of the casting, the analogs were inserted in the mold; 120 g of gypsum stone type IV (Fujirock EP, GC America) was mechanically spatulated under vacuum for 30 seconds, poured into small portions until complete filling of the mold. Plastic boxes were used as auxiliary molds in the plaster casting, allowing the standardization in the format and quantity of plaster employed for the casting. After 60 minutes, the transfer screws were unscrewed again, and the mold/cast assembly was separated, providing the replica of the master cast (Fig 2). For each group, eight casts were produced. The obtained casts were stored at room temperature for at least 120 hours until measurements were taken.

### Vertical Malalignments (2D)

The metal bar was screwed into the leftmost analog (analog A) in each cast obtained and in the master cast (control group) with a titanium screw with a 10-Ncm\(^\text{18}\) torque to maintain a stable structure position. At the same time, measurements were made on the contralateral analogs (C and D). Subsequently, the screw was removed from analog A and screwed to the right posterior analog (analog D), while the process of reading the mismatches was done on analogs A and B (Fig 3).\(^\text{1,19,20}\)

The same positioning was standardized (posterior base of the cast supported on the magnifying...
glass base) to carry out the measurements, both in the master cast and in the experimental casts. All the measurements used the same intensity of light and angle of incidence with the same distance from the cast to the magnifying glass. A LEICA loupe (manufactured in Singapore) was used to enlarge (100×) and record the image of the gap formed between the metal structure and the analogs. Slit measurements were made using the LEICA QWin program (Leica Imaging Systems). For each analog, 12 readings per test were performed: one in the center and two in the lateral region (Fig 4).

3D Overlap Evaluation Using Digital Images from Scanning

The experimental and master casts were scanned by the Contact Scanner (MDX-40, Roland, CTI), calibrated at 0.2 mm (the contact tip on the scanned surface), generating *.STL image files that were exported to the Bio-CAD (Computer Assisted Desing, Rhino3D, Rhinoceros) program to overlap the images and analyze the accuracy between the digitalized and master casts. This overlapping of the images was guided by the pyramid present in the casts. If the experimental cast had any defect on the pyramid, it was discarded. A new impression was made to produce new casts for the study, maintaining standardization and reproducibility of the analyses.

The points of each face of the pyramid were initially selected using the Bio-CAD program, and plans were projected from these points, forming an intersection point and edges between them. With the edges and intersection point defined, it was possible to overlay the experimental cast files with the master cast, acting as a reference for this overlap. In this way, it was possible to evaluate the difference in the position of the 3D analogs (in the x-, y-, and z-axes) of the casts of the experimental groups and the master cast, with the intersection point between the planes of the pyramid being the absolute position 0 in the x (lateral), y (anteroposterior,) and z (vertical). With this, it was possible to calculate the absolute position of the A, B, C, and D analogs with the position of the pyramid’s point of intersection by the Bio-CAD program (Fig 5).

Statistical Analysis

The results were analyzed statistically by the SigmaStat version 3.11 program (Systat Software) to establish the conclusions. The normality test and equality of variance were done to decide the best statistical test to be used for each comparison to be made. To analyze the vertical malalignments, 2D and 3D overlap evaluation were applied with the nonparametric Kruskal-Wallis test (failure in normality) and one-way analysis of variance (ANOVA) with the Tukey test, respectively.
RESULTS

Vertical Malalignments (2D)
There was no statistically significant difference ($P > .05$) between the groups (Table 2). Regardless of the bonding technique between the transfers and the type of tray used, the values of global marginal malalignment between the metallic infrastructure and the analogs, which were found, did not present discrepant numbers. It is important to note that the multifunctional guide with metal and resin splinted transfers are not statistically significantly different from the multifunctional guide and resin splinted transfers, 181.18 μm and 99.22 μm, respectively, even with a higher malalignment value.

3D Overlap Evaluation Using Digital Images from Scanning

Results by Axis. There was no statistically significant difference between the groups for the x-axis, the y-axis, the combination of the xy-axes, the combination of the yz-axes, and the xyz combination axes.

- z-axis: There was a statistically significant difference between the groups ($P = .037$, Table 3).
- xz-axis: There was a statistically significant difference between the groups ($P = .032$, Table 4).

Results by Analog. There was no statistically significant difference between analogs A, B, and D. However, analog C presented a statistically significant difference between the groups ($P = .037$, Table 5).

DISCUSSION

The oral rehabilitation of edentulous patients with implant-supported fixed complete dentures presents favorable aspects of occlusal loads due to their rigid bond and polyhedral arrangement. However, for their success, the bond must be rigid and passive between

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### Table 2 Median Values of Global Malalignment (in μm) Between the Metallic Infrastructure and Analogs

<table>
<thead>
<tr>
<th>Groups</th>
<th>Malalignment (μm)</th>
<th>Interquartile range</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM</td>
<td>142.8</td>
<td>72.94</td>
<td>123.42</td>
<td>272.89</td>
</tr>
<tr>
<td>GMM</td>
<td>181.18</td>
<td>119.43</td>
<td>46.33</td>
<td>502.8</td>
</tr>
<tr>
<td>GMR</td>
<td>99.22</td>
<td>89.16</td>
<td>26.78</td>
<td>525.57</td>
</tr>
<tr>
<td>MPM</td>
<td>139.55</td>
<td>86.06</td>
<td>37.75</td>
<td>496.58</td>
</tr>
<tr>
<td>MPR</td>
<td>134.36</td>
<td>102.15</td>
<td>26.7</td>
<td>419.52</td>
</tr>
<tr>
<td>MMM</td>
<td>163.06</td>
<td>146.34</td>
<td>33.3</td>
<td>469.82</td>
</tr>
<tr>
<td>MMR</td>
<td>154.55</td>
<td>174.35</td>
<td>37.06</td>
<td>429.25</td>
</tr>
</tbody>
</table>

Median values of global marginal malalignment (in μm) between the metallic infrastructure and analogs. H = 11.0472; Degrees of Freedom = 5; $P = .0505$.

### Table 3 Mean of the Difference (in μm) of the Analogs (A, B, C, and D) to the Z-axis Between the Experimental and Master Casts

<table>
<thead>
<tr>
<th>Groups</th>
<th>Malalignment (μm)</th>
<th>95% confidence interval for mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMM</td>
<td>563AB</td>
<td>401.9–725.3</td>
<td>193.4</td>
</tr>
<tr>
<td>GMR</td>
<td>772B</td>
<td>789.0–1,106.7</td>
<td>190.0</td>
</tr>
<tr>
<td>MPM</td>
<td>487A</td>
<td>326.2–715.1</td>
<td>232.6</td>
</tr>
<tr>
<td>MPR</td>
<td>615AB</td>
<td>515.0–910.5</td>
<td>236.5</td>
</tr>
<tr>
<td>MMM</td>
<td>531AB</td>
<td>529.3–805.7</td>
<td>165.2</td>
</tr>
<tr>
<td>MMR</td>
<td>681AB</td>
<td>562.8–1,077.7</td>
<td>307.9</td>
</tr>
</tbody>
</table>

Equal letters indicate statistical equality ($P > .05$).

### Table 4 Mean of the Difference (in μm) of the Analogs (A, B, C, and D) to the XZ-Axis Between the Experimental and Master Casts

<table>
<thead>
<tr>
<th>Groups</th>
<th>Malalignment (μm)</th>
<th>95% confidence interval for mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMM</td>
<td>1,061AB</td>
<td>724.6–1,205.2</td>
<td>287.4</td>
</tr>
<tr>
<td>GMR</td>
<td>1,380B</td>
<td>1,128.0–1,784.0</td>
<td>391.8</td>
</tr>
<tr>
<td>MPM</td>
<td>888A</td>
<td>595.9–1,110.6</td>
<td>307.7</td>
</tr>
<tr>
<td>MPR</td>
<td>1,110AB</td>
<td>844.7–1,371.5</td>
<td>315.1</td>
</tr>
<tr>
<td>MMM</td>
<td>934AB</td>
<td>714.1–1,282.9</td>
<td>340.1</td>
</tr>
<tr>
<td>MMR</td>
<td>1,280AB</td>
<td>965.4–1,698.9</td>
<td>438.6</td>
</tr>
</tbody>
</table>

Equal letters indicate statistical equality ($P > .05$).

### Table 5 Mean Difference (in μm) in the x, y, and z-Axes to Analog C Between the Experimental and Master Casts

<table>
<thead>
<tr>
<th>Groups</th>
<th>Malalignment (μm)</th>
<th>95% confidence interval for mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMM</td>
<td>302A</td>
<td>193.5–349.0</td>
<td>93.0</td>
</tr>
<tr>
<td>GMR</td>
<td>492B</td>
<td>362.0–581.5</td>
<td>131.2</td>
</tr>
<tr>
<td>MPM</td>
<td>315AB</td>
<td>175.7–385.0</td>
<td>125.1</td>
</tr>
<tr>
<td>MPR</td>
<td>396AB</td>
<td>255.7–497.8</td>
<td>144.7</td>
</tr>
<tr>
<td>MMM</td>
<td>366AB</td>
<td>234.3–459.2</td>
<td>134.4</td>
</tr>
<tr>
<td>MMR</td>
<td>436AB</td>
<td>315.8–490.7</td>
<td>104.5</td>
</tr>
</tbody>
</table>

Equal letters indicate statistical equality ($P > .05$).
multiple implants. This passivity confers the prosthesis a biomechanical balance that will lead to clinical success. Thus, one of the main objectives in the manufacture of an implant-supported fixed complete denture is to obtain a metallic or ceramic infrastructure that has a passive fit when placed on multiple implants.2,20,21

When using this type of prosthesis, several variables can interfere in the passive adaptation of the infrastructure, such as the impression material used, the method for transfer bonding, the use of different types of media (plastic tray, metal tray, and multifunctional guide) to perform the casting, the amount of gypsum used in the casting, and the inclination of the implants, among others.9,17,22 Thus, some of the variables of the present study were controlled to standardize them, such as the use of a standard amount of gypsum during mold casting; the use of prototyped multifunctional guides, plastic trays, and metal trays for impression; the same settling pressure in all impressions; the readings always being made by the same operator; and always reading the slots by the same angle.

In the present study, no statistically significant differences were found between the groups when using the vertical malalignment method to evaluate the accuracy of the impression technique. This probably occurred because only polyvinyl siloxane (regular and dense consistencies) was used as an impression material. Morford et al23 (1986) and Ozan and Hamis24 (2019) considered it more stable and precise than any other impression material with a rubber base, stabilizing the transfers inside the mold, generating casts with similar results. Lee et al25 (2008) found that the higher stiffness of the material provides more excellent resistance against deformation of this by some factor during the impression, for example, screwing the analogs. Moreover, for Kurtulmus-Yilmaz et al26 (2014), the material has excellent elastic recovery, giving the material good resistance and better stabilization of the transfers.

However, to evaluate the accuracy of the implant impression, 3D evaluation is recommended because distortions in the impression can occur on the x-, y-, and z-axes, so it is crucial to analyze the distortion in these three dimensions.10,27,28 Two-dimensional evaluation (record of vertical maladjustment) is not as reliable since the malalignment may be in a region where the reading is not being performed. Also, measurements were made on the analogs after bar-screwing only in a contralateral analog, which amplifies the values of the slits and makes the 2D evaluation method less accurate and reliable than the 3D evaluation. Another relevant factor is that the experimental cast maladjustment measurements are made from a bar that already had a considerable malalignment in the master cast.

In the present study, when using the 3D evaluation method (on the x-, y-, and z-axes) of the casts obtained from touch scanning to evaluate the accuracy of the impression technique, a statistical difference was observed in the z-axis between the multifunctional guide with resin splinted transfers (772) and plastic tray with metal and resin splinted transfers (487) groups. Statistical differences were also observed between these groups when evaluated in the xz-axis combination. The multifunctional guide with resin splinted transfers group averaged 1,380 μm, and the plastic tray with metal and resin splinted transfers group had a mean of 888 μm. Many authors indicate the need to stabilize the transfers to avoid rotational movements during screwing of the analog and ensure the position of the mold, generating more precise casts.9,24,28,29 The more stable and rigid this bond, the more accurate the casts, explaining the fact that the plastic tray with metal and resin splinted transfers group presented better results than the multifunctional guide with resin splinted transfers group, probably because the transfers were bonded with metal and resin (more rigid and stable bond). Vigolo et al29 (2003) verified the importance of avoiding the movement of the transfers inside the impression material in all the procedures related to the manufacture of the casts to obtain greater precision of the work. However, this is still a controversial point in the literature since some studies could not find differences between impressions with bound and unbound transfers.

Despite the advantages that the full-arch rehabilitation supported by four implants can offer in situations with anatomical and bony limitations, this type of rehabilitation hinders the impression procedure, making it difficult to obtain an accurate cast and, consequently, the prosthesis with passive seating. The implant angulation can cause a less-precise impression than parallel implants, especially in four or six implants.26 Kurtulmus-Yilmaz et al26 (2014) showed that implant angulation has significant effects on impression accuracy. However, Shim et al30 (2015) observed that up to 15-degree angulations have no significant difference in the impression result, especially when these angles are in the mesiodistal direction. Vestibular-lingual angulations were shown to have a more significant effect on the absolute precision.

On the other hand, Ehsani et al31 (2014), through three-axis evaluation (x, y, and z), observed that angled implants have no significant difference compared with the parallel implants. In this study, when the analog evaluation was performed, a difference was observed only between the metal tray with metal and resin splinted transfers (366 μm) and metal tray with resin splinted transfers (436 μm) groups for the C analog (which is a parallel implant), with no difference between angled implants. Most of the literature studies that state that implant angulations significantly affect the accuracy of
the impression did this evaluation in impressions performed directly on the implant platform, which is different from the present study, where the impressions were performed with the conical component transfers (Micro-Unit). This component has 20 degrees of conicity, and it is easier to achieve a better adaptation in clinical situations where the implants have different angulations between them.

In the study by Del’acqua et al11 (2012), it was found that the rigidity of the metal tray mold ensured better results than the plastic tray in polyvinyl siloxane transfer impressions. Thus, these authors demonstrated that the rigidity of the mold used in the impression could influence the accuracy of the casts, which explains the results of the impression techniques. However, this study did not observe differences in the results (2D and 3D) when comparing different types of trays (metal, plastic, and multifunctional guide), corroborating the results of Al Quran14 et al (2012) and the systematic review by Flügge et al9 (2018), which concluded that the bonding technique of the transfer seems to influence the final precision of the mold more than the stiffness of the mold.

When comparing the methods to evaluate the accuracy of the impression technique, it has been observed in the literature that the 3D evaluation methods seem to be more reliable and accurate, showing in three dimensions where the impression of the impression technique is,10,28,32 unlike assessment methods that use 2D measures that fail to assess inaccuracies in all dimensions and can often not be detected. Therefore, it must be prioritized in the present study that the results found when using the 3D evaluation method (in the x-, y-, and z-axes) of the casts were obtained from touch scanning.

Clinically, during the impression, several other factors may influence the quality of the impression that were not verified in the present study because it was in vitro, such as the presence of saliva, higher oral cavity temperature, muscle strains, impression material in certain regions, and impression performed with the patient in occlusion. Therefore, clinical studies should be performed to evaluate the significance of the present study results and whether the differences found will influence implant/prosthesis survival.

CONCLUSIONS

Within the limitations of this study, the following conclusions can be made. There was no statistically significant difference between the groups using the values of global marginal malalignment (2D) between the metallic infrastructure and the analogs. In the 3D analysis by analogs, for the multifunctional guide impression, the bonding technique of the transfers with metallic rods presents better results. The bonding with metal and acrylic resin presented better results than the bond with only acrylic resin when using the plastic tray and multifunctional guide, respectively, in the z-axis and the combination between the xz-axes. The evaluation methods for the accuracy impression technique presented different results between them.

ACKNOWLEDGMENTS

The authors reported no conflicts of interest related to this study.

REFERENCES