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Accuracy of Impression Techniques for Implants. Part 1 – Influence of Transfer Copings Surface Abrasion

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Abstract

Purpose: This study evaluated the influence of surface abrasion of transfer copings to obtain a precise master cast for a partially edentulous restoration with different inclinations.
Materials and Methods: Replicas (N = 30) of a metal matrix (control group) containing two implants at 90° and 65° in relation to the benchtop were obtained using a polyether impression material and three impression techniques: square impression copings splint with dental floss and autopolymerizing acrylic resin (TRS), square impression copings abraded with aluminum oxide (TA), and square impression copings abraded with aluminum oxide and adhesive-coated (TAA). The replicas obtained in type V stone were digitalized, and the images were exported to AutoCAD software to perform the readings of possible degree alterations in implant inclinations. The results were submitted to analysis of variance (ANOVA) and Tukey test ($\alpha < 0.05$).
Results: Comparing the techniques with regard to the 90° implant inclination, no statistical difference was observed between the three techniques and the control group. Analyzing the three techniques with regard to the 65° implant inclination, no significant difference was seen between technique TA and the control group.
Conclusions: Technique TA presented more accurate master casts than TRS and TAA techniques. The angulated implant (65°) tended to generate more imprecise master casts than implants perpendicular to the surface.

Initially, osseointegrated implants were used for rehabilitation of edentulous patients with the principal objective of replacing conventional complete dentures with an implant-supported prosthesis. Expanded applications of implant dentistry now include partially edentulous, single-tooth, and implant overdenture treatments.

The connection of a fixed partial denture (FPD) with implants provides a complete arch restoration in which the implant prosthesis, the implants, and bone act as a single unit.[1,2] Any misalignment, visible or not, of the prosthodontic components with the implants may induce internal stresses in the FPD/implants/bone matrix set.[3] The misfit of a prosthesis has been implicated as an etiologic factor in the development of complications for implants and their components.[4] Thus, oral rehabilitation should be initiated with adequate and individualized prosthodontic treatment planning for each clinical situation, to provide satisfactory esthetics and function once the prosthesis has been placed intraorally.

One of the most important factors for the success of an implant prosthesis is the accuracy of the impression procedure,[5,6] in order to obtain the original position of the implants during the processing of the master cast and to allow the passivity of the framework casting to its supporting abutments[7] without interference between the prosthesis–implant connection.[8,9]

The development of impression techniques to accurately record implant position has become more complicated and challenging. Several impression techniques have been suggested to achieve a master cast that will ensure the passive fit of a prosthesis on implants.[10,11] Zarb and Jansson[12] emphasized the importance of splinting transfer copings together with dental floss and autopolymerizing acrylic resin intraorally before registration of the definitive impression. Other authors[13-17] also recommend the association of the transfer copings splinting and open tray impression techniques to ensure maximum accuracy for the master casts. In contrast, Humphries et al,[18] Hsu et al,[19] Herbst et al,[20] Spector et al,[21] Inturregui et al,[22] and Phillips et al[23] indicated that splinting is unnecessary and involves extra time. Burawi et al[24] reported that the splinting technique demonstrates a greater deviation from the master cast than the unsplinted technique.

Vigolo et al[11] stated that many complicated and time-consuming techniques have been described to achieve passively fitting prostheses in situations involving multiple implant restorations. Therefore, they evaluated the accuracy of different impression techniques for multiple implants using square impression copings previously airborne-particle abraded and coated with manufacturer-recommended impression adhesive before final impression procedures. According to the authors, improved accuracy of the master cast was achieved when the airborne adhesive-coated copings were used, because airborne-particle abrasion and adhesive coating of the impression copings decrease the degree of micromovement of the copings inside the impression material from impression making to impression pouring.

Different implant angulations in relation to the alveolar ridge are also a common variable in clinical practice. Assunção et al[13] evaluated the effect of various implant angulations (90°, 80°, 75°, and 65°) associated with different impression transfer techniques and materials and demonstrated that a more accurate impression was provided when an implant was less angulated.

Thus, many factors can alter the master cast accuracy, leading to absence of passive fit between the implant and prosthesis. Various investigations[13,18,21] have assessed the accuracy of impressions transfer involving four to six implants; however, it is also important to delineate accuracy for smaller prostheses supported by two implants.[25]

The aim of this in vitro study was to evaluate the influence of square impression coping abrasion with and without the use of adhesive, and a nonsurface-abraded square impression joined with floss and acrylic resin, during impression transfer of implants with different inclinations (90° and 65°) to obtain a precise master cast for a two-implant prosthesis and to compare the analog inclination with metal matrix block implant inclinations.

Materials and methods

A metal matrix measuring 3.5 × 2.0 × 2.0 cm^3 was fabricated using anodized aluminum. Two implants with external connections of 3.75 × 10.0 mm^2 (Conexao, Conexao Prosthesis Systems, Inc, Sao Paulo, Brazil) were positioned at 90° and 65° in relation to the horizontal matrix surface (Fig 1), representing a two-implant partially edentulous arch. A 3-mm thick wax spacer[26] was placed on the metal matrix involving the square impression copings that had been screwed into the implants of the metal matrix. Thus, 30 customized open impression trays were fabricated using autopolymerizing acrylic resin (Jet, Classico Dental Products Ltd, São Paulo, Brazil), allowing uniform thickness of the impression material.

Ten impression transfer specimens were made with medium viscosity polyether material (Impregum Soft, 3M ESPE Dental Products, Medizin, Germany) with square impression copings for each of three transfer impression techniques, represented by three groups. In the first technique (group TRS), square impression copings (Conexao) were joined together with dental floss scaffolding (Sanifil, Facilit Dental and Perfumary Ltd., Rio de Janeiro, Brazil) covered with autopolymerizing acrylic resin

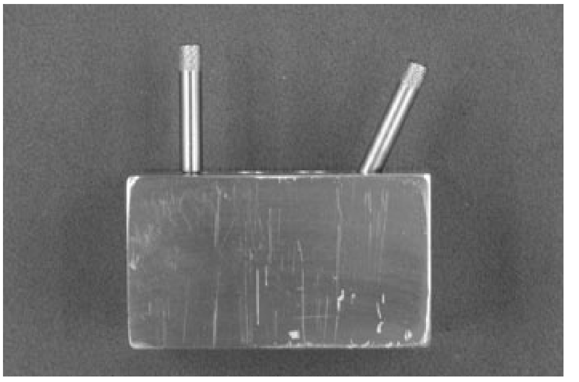

Figure 1 Metal matrix with implants at 90° and 65° inclination in relation to the surface.

(Duralay, Reliance Dental Mfg. Co, Worth, IL). The acrylic splint of the impression copings was done as a bulk procedure without sectioning and reindexed with a smaller volume of resin after it initially set[23] (Fig 2).

In the second technique (group TA), square impression copings were abraded with 50-μ aluminum oxide (Bio-Art Odontological Equipments Ltda., Sao Carlos, SP, Brazil) under 75 lbs pressure, before the impression procedure (Fig 3).

In the third technique (group TAA), square impression copings were abraded with aluminum oxide, as previously described in technique 2 (group TA), and coated with adhesive (Polyether Adhesive, 3M ESPE)[10,11] (Fig 4). All materials were used according to their respective manufacturers' recommendations. Before all impression procedures, the customized open impression tray was coated with an adhesive tray coating (Polyether Adhesive, 3M ESPE) adequate for the impression material used.

A 5-kg metal block exerted a standardized pressure over each tray during the polymerization of the impression material. This was enough to allow the excess material to flow out and to maintain constant pressure throughout the working time. The impression/matrix set was placed in distilled water[13] at 36 ± 1°C during the polymerization time, determined by the manufacturer.

After polymerization, the impression/matrix set was separated, and machining implant replicas (Conexao) were screwed into the square impression copings embedded in the impression. Thirty minutes after the impression/matrix set, separation was carried out using a type V stone plaster (Durone, Denstsply Industry and Trade Ltd., Petropolis, RJ, Brazil), in a proportion of 30 g of stone:9 ml of water (recommended by the manufacturer) spatulated in a vacuum mechanical mixer (Turbomix, EDG Equipments and Controls Ltd, Sao Carlos, SP, Brazil) for 60 seconds and poured under constant vibration (Vibramaster, Knebel Dentarios Products Ltd., Porto Alegre, RS, Brazil). After 120 minutes, the impression/master cast was separated to obtain the specimens. With these procedures, 30 matrix replicas were obtained representing the three groups (n = 10): group TRS (transfers resin splinted), group TA (transfers air abraded), and group TAA (transfers air abraded adhesive), previously

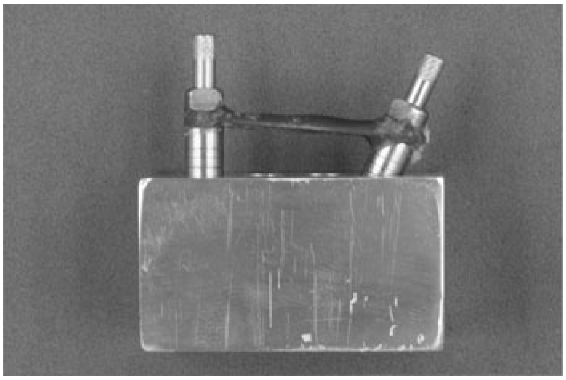

Figure 2 Square impression copings splinted with dental floss and autopolymerizing acrylic resin.

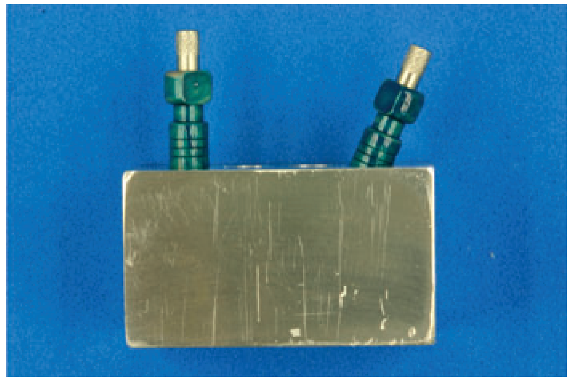

Figure 4 Square impression copings abraded with aluminum oxide and coated with adhesive.

described. The metal matrix and its implants served as the control group (M).

The implant analogue's inclination was recorded in degree of inclination for each specimen and compared with metal matrix implants inclination (M), using graphic computation software AutoCAD (AutoCAD 2000, AutoDesk, Inc, San Rafael, CA), which is the software often used for measurement of angles.[27,28] For this, each replica and the metal matrix were digitalized in a scanner (Scan Jet 6100C, Hewlett Packard, Palo Alto, CA), where the benchtop was perpendicular to the scanner table, and all the images of the specimens were put in the scanner in the standardized position with the help of a metal device fixed in the glass table of the scanner (Fig 5).

To determine the long axis of each implant replica, the impression transfer screw was screwed into the implant replica before the digitalizing process. Sequentially, the digitalized images were exported to AutoCAD software to carry out the angular measurement of possible alteration of inclination implant analog in each situation (90° and 65°). For this, three lines were created: one line in each lateral surface of the transfer screw in accordance with its inclination (90° and 65°), and one line parallel to the benchtop (Fig 6). These three lines were used to establish reference points to carry out the measurements through the angular dimension toolbar of the AutoCAD software (Fig 7). All angular measurements were determined in degrees and recorded by the same operator, who was blinded as to which group was being evaluated. The operator variability was assessed using the mean of three repeated measurements for each implant inclination (90° and 65°) in one randomly selected specimen from each condition (TRS, TA, and TAA). Among these three repeated measurements those three lines were repositioned to refine their alignment with the replicas. In this way, six readings for each specimen, 60 readings for each group, and 180 readings for the three groups were recorded in addition to three readings for each implant in the metal matrix, totaling six measurements in this group (control).

The data obtained from the readings for each group were analyzed, and for each implant inclination were submitted to statistical analysis for the two test conditions. Initially, the groups TRS, TA, and TAA were compared for each inclination (90° and 65°), independent of the metal matrix (control group). The three groups were then compared with the data obtained from the (control) metal matrix readings. For this, the absolute differences among the TRS, TA, and TAA group readings were compared with the metal matrix values. The comparison between the treatments and between the treatments and the control group for each inclination were made by analysis of variance (ANOVA) and Tukey test ($\alpha < 0.05$).

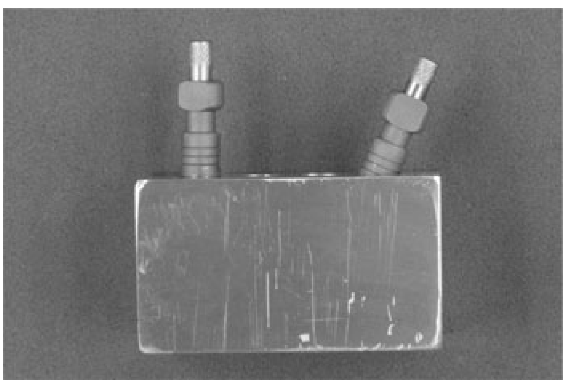

Figure 3 Square impression copings abraded with aluminum oxide.

Figure 5 Replica digitalized in a scanner with help of metal device.

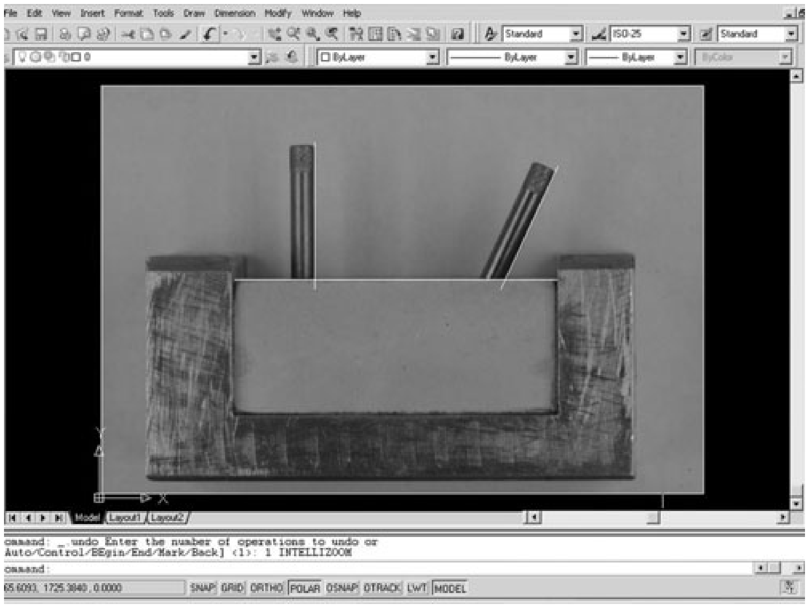

Figure 6 Three straight lines created in each specimen to obtain angular measurement of inclination implant analog through AutoCAD software.

Results

The data obtained were submitted to ANOVA and Tukey tests for results verification, using the Sanest program (Statistic Analysis System, Zonta & Machado, Pelotas, RS, Brazil) with unmodified data (Tables 1-3).

Table 2 demonstrates no significant statistical difference among the three groups or between these groups and the control group, when the techniques were analyzed specifically for the 90° inclination implant. When analyzing the three groups of impression transfer techniques specifically for the 65° inclination implant (Table 3), no statistical difference was observed between the TA group and the control group ($\alpha > 0.05$), while the TRS group demonstrated a statistically significant difference from the TA group and the control group ($\alpha > 0.05$). The TAA group presented intermediate values.

Discussion

Long-term success in implant prosthodontics depends not only on osseointegration of implants, but also on maintenance after the prosthetic installation is placed into function.[14] For this, a prosthesis superstructure must passively fit the implant or

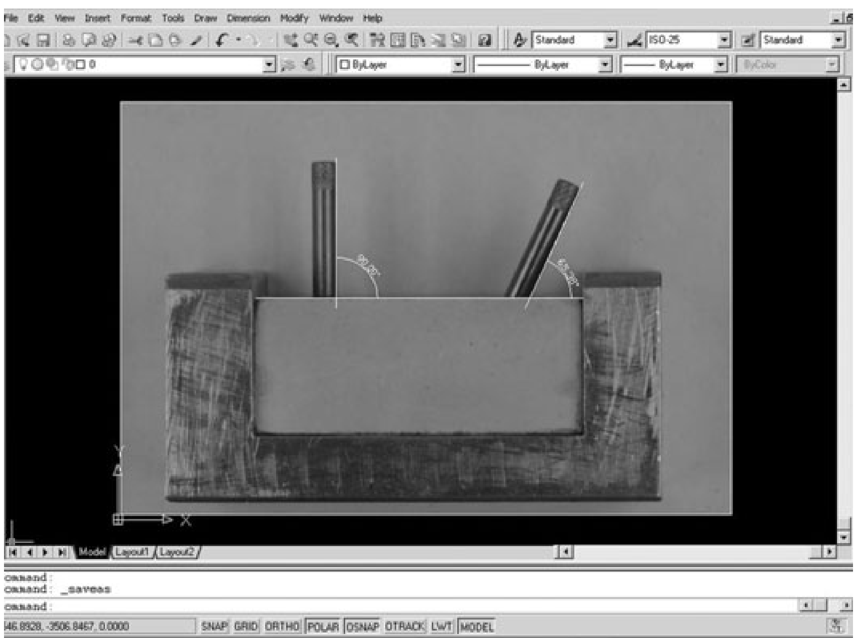

Figure 7 Measurements of inclination implant analog through the angular dimension toolbar of AutoCAD software.

Table 1 ANOVA (Factors: group and inclination)

Causes of variation	df	SS	MS	F	*P*-value
Group	3	7.5176017	2.5058672	5.8383	0.00159
Inclination	1	11536.3918057	11536.391805	26878.0699	0.00001
Group × inclination	3	3.9890484	1.3296828	3.0980	0.03141
Error	72	30.9032685	0.4292121		
Total	79	11578.8017242			

df = degrees of freedom; SS = sum of squares; MS = mean square; General mean = 77.703125; coefficient of variation = 0.843 %.

abutment interface with retention screws secured at the proper preload. Misfit and lack of passivity have been implicated as etiologic factors in the development of complications, because implant components fracture due to fatigue loading, loss of preload of the retention screws, marginal bone loss, and even loss of osseointegration.[2]

The accuracy of the impression procedure may contribute to lack of passive adaptation of the framework casting to its supporting abutments and/or implants,[7] because the master cast obtained from the impression is the foundation for the fabrication of the implant prosthesis. The impression stage is a phase that may contribute to complications of an implant prosthesis, because an inadequately recorded impression will result in an inaccurate master cast and ultimately lead to a compromised/misfit implant prosthesis. This, in turn, could contribute to failure of the entire system's long-term prognosis, resulting in possible compromise of hard and soft tissues, implants, or the bone/implant interface. Thus, all implant transfer impression techniques have been developed with the aim of making master casts more accurate to assist in achieving a passively fitting implant superstructure. Increased attention is necessary when recording/making impressions of implants placed in limited spaces with unfavorable positions or at adverse angulations.

Many authors[12–15] recommend splinting of the square impression copings when recording an implant impression to avoid impression coping movement and distortion of the impression and 3D spatial orientations of the implants' positions, thereby ensuring accuracy of master casts; however, in the present investigation, the TRS group (transfer joined together with autopolymerizing acrylic resin) showed less accuracy of master cast than did the control group, when assessed at 65° implant analog inclination (Table 3).

It should be noted that it is difficult to ensure the splint's stability. The dental floss scaffolding can be exaggerated, and different amounts of autopolymerizing acrylic resin can be used during the transfer union. This may result in different splint stiffness and, consequently, transfer dislocation during the impression procedure. Another aspect to be considered is the effect of polymerization shrinkage of the resin once the impression is recovered and the master cast is poured when the splint of the impression copings with resin was done as a bulk procedure, without sectioning and splinting the resin after it initially set.[23,24] Additionally, it should be noted that these procedures, when carried out intraorally, are more difficult to execute, with a lower accuracy and a greater use of clinical time.

Authors who found similar results to those of this study[18–20,23] also did not find any significant difference in the accuracy of the cast obtained through the transfer impression using the unsplinted technique or the acrylic resin splinted technique. Burawi et al[24] even reported that the splinted technique exhibited more deviation from the master model than the unsplinted technique did, and this was primarily associated with rotational discrepancies around the long axes of the implants for the splinted technique.

In this study, the TA group (transfers air abraded) demonstrated adequate accuracy of the master cast in all situations evaluated (90° and 65° implant analog inclination). The mean remained close to that of the control group, and no significant difference at the 5% level was observed between the control and TA groups.

Vigolo et al[10] evaluated in vitro the accuracy of definitive casts obtained from transfer impressions using square copings for the replacement of one tooth. In the first group, nonmodified square impression copings were used; in the second group square impression copings previously airborne-particle abraded and coated with manufacturer-recommended impression adhesive were used. It was observed that displacement abutment positions in the specimens were significantly smaller

Table 2 Tukey test for group mean in relation to 90° inclination factor*

Group	Specimen means (degrees)										Group means (standard deviation)	5%
	1	2	3	4	5	6	7	8	9	10		
TRS	89.5	89.5	89.4	89.9	89.9	89.5	89.6	89.7	89.4	89.6	89.6 (1.0)	a
TAA	89.4	92.3	89.0	91.6	89.3	90.1	89.3	89.4	89.8	90.2	90.0 (1.0)	a
TA	89.9	89.7	89.3	89.9	89.6	89.7	89.0	89.7	88.9	89.6	89.5 (0.3)	a
M‡	89.4	89.4	89.4								89.4 (0.0)	a

*Mean values are significantly different when followed by different letters in final column ($\alpha < 0.05$).
‡Control group.

Table 3 Tukey test for group mean in relation to 65° inclination factor*

	Specimen means (degrees)											
Group	1	2	3	4	5	6	7	8	9	10	Group means (standard deviation)	5%
TRS	66.3	66.0	66.4	66.1	66.8	66.4	65.7	65.7	68.4	65.8	66.4 (0.8)	a
TAA	65.5	64.6	66.0	66.3	65.9	65.3	66.4	66.5	65.7	65.9	65.8 (0.5)	ab
TA	66.1	65.5	65.3	65.0	65.7	63.7	63.0	65.8	66.3	65.2	65.2 (1.0)	b
M‡	65.3	65.2	65.2								65.2 (0.0)	b

*Mean values are significantly different when followed by different letters in final column ($\alpha < 0.05$).
‡Control group.

in casts obtained from modified transfers than nonmodified transfers. The authors concluded that impression transfer accuracy increases when copings are airborne-particle abraded and adhesive-coated. In another study, Vigolo et al[11] evaluated the accuracy of three impression techniques, using square copings and medium viscosity polyether as impression material. In the first technique, nonmodified square impression copings were used, and in the second technique, square impression copings were used and joined together with autopolymerizing acrylic resin before the impression procedure, and in the third technique, square impression copings previously airborne-particle abraded and coated with the manufacturer-recommended impression adhesive were used. In the results, both the second (the resin-splinted) and the third technique (air-particle abraded) showed an improved accuracy of the master cast when compared with the first technique (nonmodified square impression copings).

In the current study, the results of group TAA (transfers air abraded adhesive) were different than expected. When the 90° inclination implant analog was analyzed, the TAA group did not present a statistically significant difference from the control group. Analyzing the 65° inclination implant, the TAA group showed more accuracy of the master cast than the TRS group, but lower accuracy than control and TA groups. It was expected that the TAA group would present a higher accuracy than the TA group, because the square impression copings were abraded with aluminum oxide and also received an adhesive-coated layer, which should theoretically allow less movement of the copings. A hypothesis for these obtained results lies in the adhesive-coated layer, which may make the copings' surface less rough and could allow greater movement of the copings, so that the mechanical union between the impression material and the rough surface is higher than with the adhesive layer.

This study suggests the use of abraded square impression copings without adhesive in the impression phase to improve the accuracy of the master casts, because this technique reduced the freedom of rotational movement of the impression copings inside the impression material during the clinical and laboratory phases, contributing to the superstructure's passive fit and, consequently reducing complications in long-term osseointegration. Additionally, the laboratory technician is able to fabricate a restoration that will ultimately require fewer intraoral modifications, especially adjustments of interproximal contacts and occlusal adjustments.[10] This technique can be chosen when an immediate loading multiple implant impression has to be done, because in these cases, intraorally splinting the square impression copings with floss and acrylic resin is not the preferred option, and there is the risk of interfering with the healing process of the recently operated tissue with the contact of the resin monomer.[11] This procedure is easily executed in the dental practice, resulting in fewer time-consuming chairside modifications and adjustments.

It may still be observed that the implant positioned perpendicular to the surface (90°) resulted in a higher accuracy of the cast in relation to the implant with 65° inclination to the surface, according to Assuncao et al.[13] Under clinical conditions and in multiple implant restorations, the angular discrepancies may result in a nonprecise fit of the metal-supporting structure and a potential need for soldering procedures. Further studies are required to evaluate techniques to ensure more accuracy in the master cast with angulated implants.

Conclusion

Within the limitations of this study and based on the results of the present investigation, accurate master casts were obtained with impression techniques using square impression copings abraded with aluminum oxide without adhesive at 90° and 65° implant inclinations. This technique is a simple and less time-consuming procedure that may be a preferred choice. In addition, working casts obtained from impression techniques using square impression copings splinted with autopolymerizing acrylic resin presented less accuracy in impressions with an implant inclination of 65°. This verified that implants perpendicular to the surface (90°) tend to generate less displacement of the transfer/analog set, resulting in more precise master casts than inclined implants (65°).

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