Accuracy of Impression and Pouring Techniques for an Implant-Supported Prosthesis

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Purpose: *The purpose of this in vitro study was to compare the dimensional accuracy of a stone index and of 3 impression techniques (tapered impression copings, squared impression copings, and squared impression copings splinted with acrylic resin) associated with 3 pouring techniques (conventional, pouring using latex tubes fitted onto analogs, and pouring after joining the analogs with acrylic resin) for implant-supported prostheses.* ***Materials and Methods:*** *A mandibular brass cast with 4 stainless steel implant-abutment analogs, a framework, and 2 aluminum custom trays were fabricated. Polyether impression material was used for all impressions. Ten groups were formed (a control group and 9 test groups formed by combining each pouring technique and impression technique). Five casts were made per group for a total of 50 casts and 200 gap values (1 gap value for each implant-abutment analog).* ***Results:*** *The mean gap value with the index technique was 27.07µm. With the conventional pouring technique, the mean gap values were 116.97 µm for the tapered group, 57.84 µm for the squared group, and 73.17 µm for the squared splinted group. With pouring using latex tubes, the mean gap values were 65.69 µm for the tapered group, 38.03 µm for the squared group, and 82.47 µm for the squared splinted group. With pouring after joining the analogs with acrylic resin, the mean gap values were 141.12 µm for the tapered group, 74.19 µm for the squared group, and 104.67 µm for the squared splinted group. No significant difference was detected among Index, square/latex techniques, and master cast (P >.05).* ***Conclusions:*** *The most accurate impression technique utilized squared copings. The most accurate pouring technique for making the impression with tapered or squared copings utilized latex tubes. The pouring did not influence the accuracy of the stone casts when using splinted squared impression copings. Either the index technique or the use of squared coping combined with the latex-tube pouring technique are preferred methods for making implant-supported fixed restorations with dimensional accuracy.* INT J ORAL MAXILLOFAC IMPLANTS 2008;23:226–236

Key words: *dental implantation, dental impression technique, dental models*

The accuracy of a master cast for treatment utilizing implants depends on the type of impression material, implant impression technique, die material accuracy, and implant master cast technique.[1] The process of implant-supported prosthesis fabrication involves the accurate transfer of intraoral records to laboratory casts. Any dimensional inaccuracy in this process will lead to a compromised result and possibly treatment failure. Therefore, the impression technique is a critical stage in this process.[2]

Different wash bulk from a putty-wash impression technique can result in dimensional changes proportional to the thickness of the wash material during setting. According to Nissan et al,[3,4] a wash thickness of 1 to 2 mm is the most accurate for fabricating stone dies. A wash thickness greater than 2 mm was found to be inadequate for obtaining accurate stone dies. However, adaptation problems between the prosthodontic components used in prosthesis fabrication, along with the laboratory steps of waxing, investing, casting, welding (ie, the technical ability of the laboratory) are also important.[5]

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The primary objective in fabricating a superstructure for osseointegrated endosseous implants is to achieve a passively fitting connection between an implant abutment and the framework.[6] Mechanical stresses can be transmitted to implants through the attachment of the framework to the abutments. However, there is currently a lack of knowledge of the biologic responses to interfacial stress transfers.[6] Furthermore, the implant does not have a periodontal ligament and cannot adapt its position to a nonpassive framework.[7]

To provide a passive fit or a strain-free superstructure, a framework should, theoretically, induce no strain on the supporting implant components and the surrounding bone in the absence of an applied external load.[8] This vital requirement may be provided by simultaneous and even connection of the complete inner surfaces of all retainers by all abutments.[8] However, an absolutely passive framework fit has not been achieved.[8,9] The main purpose of a multi-implant impression is to record and transfer the relationship between implant abutments or implants and to reproduce this relationship as accurately as possible. Implant impressions also serve the important purpose of recording soft tissue morphology.[1,10]

In the Brånemark system, both tapered and square impression copings are used to transfer the positional relationship between the abutments and their analogs. Many techniques exist for the use of this system; however, it is unclear which is best. Humphries et al[11] concluded that a technique with tapered copings is better than one using unsplinted squared or splinted squared copings. In contrast, some studies concluded that a technique with squared copings is better than one with tapered copings.[2,12] Others concluded that both techniques are equally accurate.[13–15]

Several authors have concluded that square copings connected with acrylic resin provide the best result in making impressions.[15–18] However, previous studies had demonstrated that this splinting process is unnecessary.[2,11,14,19–22]

De La Cruz et al[23] concluded that the accuracy provided by verification jigs was not significantly superior to standard impression procedures (tapered or squared copings). Their results suggest that jig fabrication does not improve the dimensional accuracy of stone casts. To minimize the alterations of the setting expansion of the dental stone, McCartney and Pearson[24] filled the compartments around the suspended laboratory abutment analogs with dental stone to form a corrected master cast.

Since there is still no consensus among researchers regarding the best impression techniques for implants, and few studies have been conducted to investigate the pouring techniques that exist, it was the purpose of this study to compare the dimensional accuracy of a verification jig and of 3 impression techniques (tapered impression copings, squared impression copings, and squared impression copings splinted with acrylic resin) associated with 3 pouring techniques (conventional pouring, pouring using latex tubes, and pouring after joining the analogs with acrylic resin) for osseointegrated implant-supported prostheses.

MATERIALS AND METHODS

A mandibular cast with 4 Brånemark stainless steel abutment replicas (Micro-Unit; Conexão Prothesis Systems, São Paulo, Brazil) was fabricated to serve as a clinically relevant simulation. The analogs were temporarily secured with acrylic resin (Duralay; Reliance Dental Mfg, Worth, IL) to make their removal possible after fabrication of the metal framework and were placed at a 90-degree angle in relation to the mandibular cast surface. Five fiducial marks (circular depressions 6 mm wide and 3 mm deep) were made on the master cast to standardize tray positioning each time during impression making.[22]

A master framework was made using titanium cylinders (Conexão; Conexão Prosthesis Systems, São Paulo, Brazil) and 2-mm-diameter cylindric titanium bars (Conexão; Conexão Prosthesis Systems, São Paulo, Brazil) using a laser-welding technique. The original analogs were removed after the welding, and new analogs (Conexão; Conexão Prosthesis Systems) were screwed into the framework copings with the aid of a calibrated torque wrench (Conexão; Conexão Prosthesis Systems) limited to 10 Ncm. The new analogs were then embedded into the master cast holes with epoxy resin (Araldite Professional 24 hours; Vantico, Taboão da Serra, SP, Brazil).[15,16,23] This produced a model with implants (Fig 1) with a passively-fitting metal framework.[17,25] This framework was the standard for the assessment of all subsequent measurements made to determine the accuracy of casts made from different impression procedures.[26]

Two custom aluminum trays fabricated by casting of a custom acrylic resin tray were used in this study. One was used for the technique with resin-splinted impression copings, and the other was used for the other 2 techniques. These trays had a 2-mm relief for impression material, with 4 windows to allow access to the coping screws and with 5 stops to standardize tray positioning during impression making (Fig 2). The surfaces of the trays were sandblasted (VH, Araraquara, SP, Brazil)[27] with 125-μm aluminum oxide to increase the bond between the impression material and the tray.

Fig 1 Metal master cast.

Fig 2 Custom aluminum tray.

A box for pouring the impression with dental stone was made with condensation silicone (Zetaplus/Oranwash; Zermack, Badia Polesine, Rovigo, Italy). This matrix was used for all of the impressions, allowing standardization of the format of the models and of the amount of dental stone employed for the pouring.

Ten groups with 5 casts each were formed:

- The index group
- Group 1a: Tapered impression copings, conventional pouring technique
- Group 1b: Tapered impression copings, pouring using latex tubes
- Group 1c: Tapered impression copings, pouring after joining the analogs with acrylic resin
- Group 2a: Squared impression copings, conventional pouring technique
- Group 2b: Squared impression copings, pouring using latex tubes
- Group 2c: Squared impression copings, pouring after joining the analogs with acrylic resin
- Group 3a: Squared splinted impression copings, conventional pouring technique
- Group 3b: Squared splinted impression copings, pouring using latex tubes
- Group 3c: Squared splinted impression copings, pouring after joining the analogs with acrylic resin

The impressions were made in a controlled-temperature environment (23 ± 2°C) with a relative humidity of 50% ± 10%. Tray adhesive (3M ESPE, Seefeld, Germany) was applied thinly and evenly over the inner surface of each tray and extended approximately 3 mm onto the outer surface of the tray along the periphery. The adhesive was allowed to dry for 15 minutes before the impressions were made.

Polyether impression material (Impregum Soft medium consistency; 3M ESPE) was used[18,28] in accordance with the manufacturer's instructions. The impression material was placed in the tray and, at the same time, was syringed around the transfer copings, followed by immediate placement of the tray loaded with impression material. The tray was seated on the master cast with gentle pressure until the stops contacted the base of the master cast. The impression material was allowed to set for 12 minutes from the start of mixing; the manufacturer's setting time was doubled to compensate for a delayed polymerization reaction at room temperature rather than at mouth temperature.[3,4,22,28] A standardized pressure of 1.25 kg was exerted over each tray during the impression procedures. This was enough to force the excess material to flow out and to maintain constant pressure throughout the working time.[18]

The fitting surfaces of all components were cleaned with isopropyl alcohol before each connecting procedure for all techniques.[22] Correct seating of the transfer copings was verified throughout the impression and pouring procedures both visually and with a probe (no. 5 Duflex - SS White, Rio de Janeiro, Brazil). Five impressions of the master cast were made for each impression transfer technique. For group 1, the tapered coping group (indirect transfer technique), the impression/matrix set was separated. Tapered copings (Fig 3) were retrieved from the cast and replaced in each notch left in the impression with brass laboratory analogs attached.

For group 2, the squared coping group (direct transfer technique), the square impression copings were unscrewed from the abutment before the impression could be removed. The squared transfer copings were secured onto the analogs with guide screws (Fig 4) and torqued to 10 Ncm using the torque driver.[29]

Fig 3 Tapered copings.

Fig 4 Squared copings.

Fig 5 Splinted squared copings.

Fig 6 Index with splinted squared copings.

For group 3, squared impression copings splinted with acrylic resin, the splinting process was initiated by placing autopolymerizing acrylic resin (Reliance Dental) around the copings. Preformed acrylic resin bars with a cross-sectional diameter of approximately 3 mm were fabricated by the injection of acrylic resin into a drinking straw.[30] Appropriate lengths of the resin bar were sectioned with a cutting disk (Intensiv SA, Grancia, Switzerland) to bridge the spaces between the adjacent transfer copings. Using a bead brush technique, the ends of the resin bar were luted to the transfer copings with acrylic resin.[30,31] An additional step of sectioning (diamond-coated disk 150 µm thick; Intensiv SA) and rejoining the acrylic resin was performed to reduce the effects of polymerization shrinkage[21,23,32] (Fig 5). The same acrylic resin splint was used to transfer the copings from the master cast to all 15 analog casts made with the splinted technique. However, the splint was sectioned and rejoined as described above before each impression was made.[22]

The connecting screws that fixed the metal copings to the abutments on the master cast were removed through the access openings. The impression, which held the splint and/or metal transfer copings, was then removed from the master cast. The laboratory analogs were fixed in position within the transfer copings and within the impression by placing and hand-tightening the guide screws through the access openings. The tightening of the guide pin, impression coping, and abutment analog complex was performed with 10 Ncm only for the splinted technique, since the 10 Ncm force applied by the torque driver caused rotation of the transfer copings in the polyether impressions in the squared-copings technique. Therefore, only hand tightening was employed with the squared-copings technique.[21]

With the verification-jig group (index group), which was considered the control group, the same steps used for the splinted-squared copings technique were followed. The splinted transfers were unscrewed from the master cast and screwed to the abutment analogs with 10 Ncm. A rectangular wax well was boxed with boxing wax and poured with die stone. The analogs were seated into the stone matrix to approximately half their length. When set, the stone index was trimmed and finished (Fig 6).[33] All casts (45 models and the 5 verification jigs)

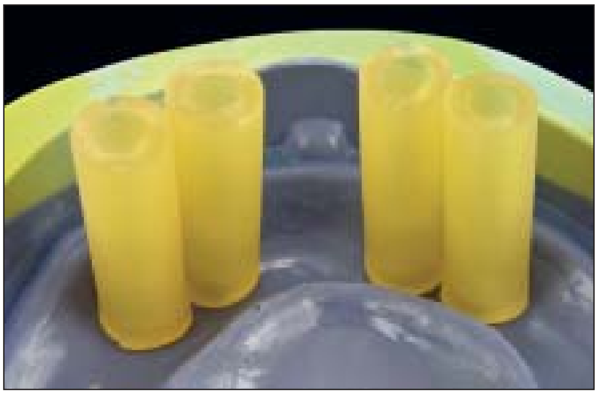

Fig 7 Latex tubes were fitted onto analogs.

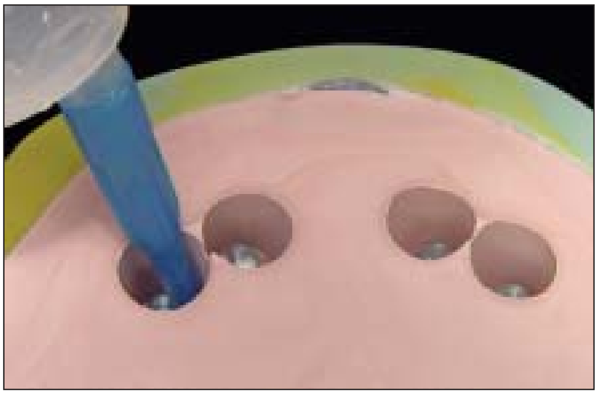

Fig 8 Dental stone being inserted around analogs.

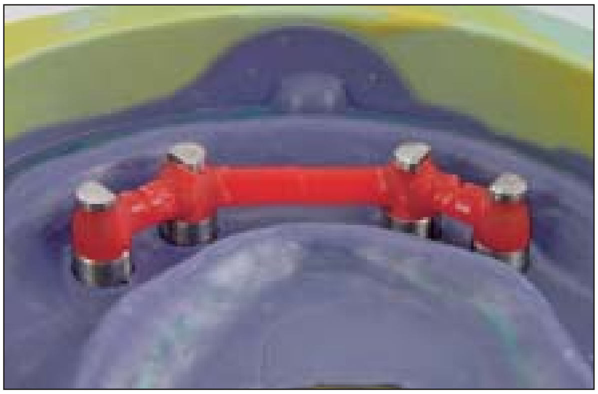

Fig 9 Splinted analogs with acrylic resin.

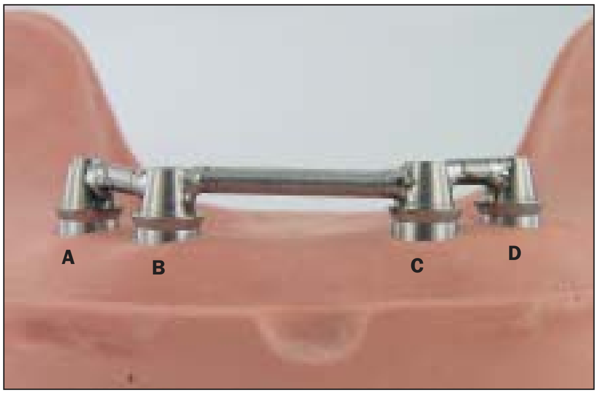

Fig 10 Framework tightened in analog A to 10 Ncm.

obtained were stored at room temperature for a minimum of 2 weeks before measurement.[4,21,22]

For the conventional pouring group (group a), the impressions were poured with a die stone (Vel-Mix; Kerr Corporation, Orange, CA) 30 minutes after the impressions were made. A ratio of 22 mL of water to 110 g of stone was used, and the stone was mixed by hand for 15 seconds to incorporate the water and then mechanically mixed under vacuum for 30 seconds with a digital vacuum spatulator (Turbomix EDG Equipment, São Carlos, SP, Brazil). All mixes were vibrated into the impression. The stone casts were allowed to set for 2 hours before separation from the impressions.

For the latex tube pouring technique group (group b), the method of McCartney and Pearson[24] was used to minimize alteration of the setting expansion of the dental stone. Four pieces of latex tube were used, each with a length of 23 mm, an internal diameter of 4 mm, and an external diameter of 8 mm (Auriflex, São Roque, SP, Brazil). The tubes were fitted onto the analogs, and pouring was performed as described for the conventional pouring technique (Fig 7). After the initial setting (approximately 10 minutes), the latex tubes were removed (Fig 8). A ratio of 6 mL of water to 25 g of stone was mixed following the process described previously and syringed (20 mL BD Plastipak syringe; Becton Dickinson, Curitiba, PR, Brazil) around the analogs.

For group c, the same procedure used in the splinted squared copings technique was accomplished with the analogs. After splinting analogs with acrylic resin (Fig 9), the pouring was performed following the conventional technique.[34]

The 4 implant analogs in the master cast were denoted sequentially A through D from left to right. The standard framework was seated on each cast and a titanium screw was tightened in analog A to 10 Ncm using a torque driver (Conexão; Fig 10), while measurements of abutment-framework interface gaps were made for analogs C and D. This process was repeated in analog D, and the measurements for analogs A and B were noted.[5,6,33,35,36]

These measurements were analyzed using software (Leica Qwin; Leica Imaging Systems, Cambridge, England) that received the images from a video camera (JVC, 0.5-inch CCD, model TK-C1380, Tokyo, Japan) coupled to a Leica stereomicroscope (Leica Microsys-

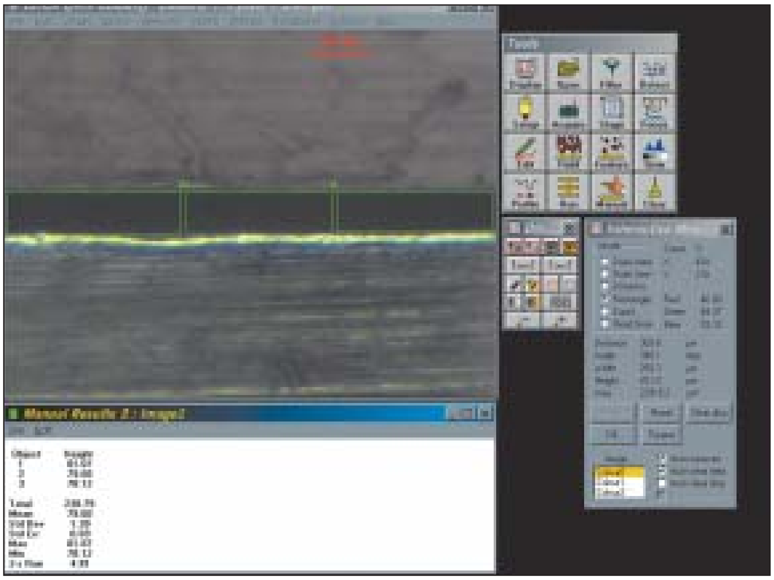

Fig 11 Abutment-framework interface gap for left area was 81.07 μm, for central area it was 79.60 μm, and for right area it was 78.12 μm, and obtained arithmetic mean was 79.60 μm.

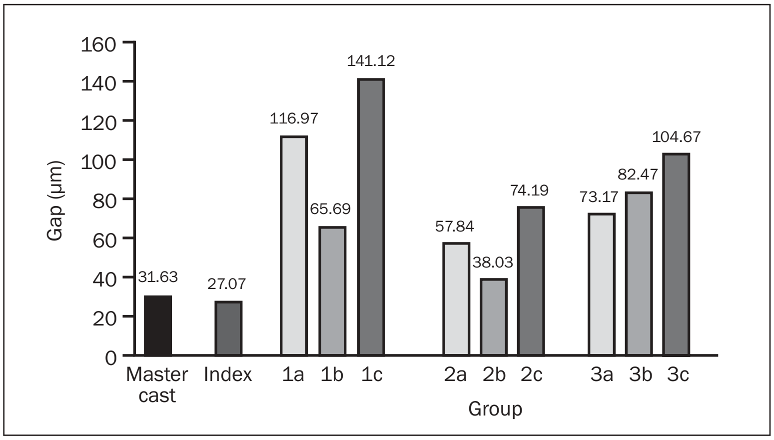

Fig 12 Mean gap values.

tems, Wetzlar, Germany) at 100× magnification. Demarcations were made in the center of the lingual side of each titanium abutment of the framework to standardize the area for image capture. For each obtained picture, lineal readings of the gap were accomplished in 3 areas. The arithmetic mean of these 3 values determined the value of the gap (Fig 11).

The mean gap value for the master case was calculated as the average of 5 consecutive measurements, and the framework was screwed in again before each measurement. Thus, 20 gap values were obtained for the master cast.

With the aid of the SigmaStat version 3.11 software (Systat, Evanston, IL), a suitable statistical test was applied for each comparison. After creating graphic normal distribution plots and box plots and running statistical adaptation tests (Kolmogorov-Smirnov and the Equal Variance Test [Levene test]) for each comparison, the application of nonparametric tests was indicated.[28]

For the purpose of paired group comparisons, the Wilcoxon rank sum test (Mann-Whitney *t*est) was applied. If several groups were considered together, nonparametric analysis of variance (ANOVA), according to Kruskal-Wallis was used. Values of $P < .05$ were judged to be significant. To isolate a group or groups that differed from the others, a multiple comparison procedure was used (Tukey test or Dunn's method). The gap values for groups with the same letter were not significantly different ($\alpha = .05$).

RESULTS

Ten groups with 5 casts each were formed for a total of 50 casts. Two hundred gap values were calculated. There were 9 test groups and 1 jig verification group; the latter was considered the control group. The mean values of abutment-framework interface gaps are shown in Fig 12. No significant difference was

Table 1 Comparison Among Impressions Poured Using the Conventional Technique

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Tukey groupings
1a	20	116.97	116.745	73.500	173.580	B
2a	20	57.84	59.905	44.715	84.390	A
3a	20	73.17	66.955	51.350	97.295	AB

H = 10.187 with 2 degrees of freedom ($P = .006$).

Table 2 Comparison Among Impression Techniques—Latex Tube Pouring Technique

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Tukey groupings
1b	20	65.69	69.215	47.285	89.4250	B
2b	20	38.03	32.310	23.800	42.8750	A
3b	20	82.47	73.220	46.435	101.595	B

H = 17.078 with 2 degrees of freedom ($P \leq .001$).

Table 3 Comparison Among Impression Techniques—Splinted Analog Pouring Technique

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Tukey groupings
1c	20	141.12	123.235	72.52	205.680	B
2c	20	74.19	72.010	53.41	101.090	A
3c	20	104.67	95.820	45.21	123.835	AB

H = 7.886 with 2 degrees of freedom ($P = .019$).

detected among the index group, group 2b, and the master cast ($P > .05$). Results of all comparisons done after the statistical analysis are listed in Tables 1 through 8.

DISCUSSION

Previous studies related to implant-supported prostheses used nonclinical casts,[1,11,14,16–18,20–23,25,26,36] clinical examples,[2,12,15,19,28] edentulous clinical casts,[1,2,11,12,14–23,25,26,28,36] and partially edentulous clinical casts.[13] In this study, an edentulous clinical cast was utilized to investigate impression and pouring techniques.

Working casts should accurately represent the clinical relationship of the implants to allow for the fabrication of passively-fitting prostheses and, consequently, the elimination of strain on the supporting implant components and the surrounding bone.[8,28]

A perfect fit occurs when all the matching surfaces of the implant and prosthesis are in alignment and contact without the application of force.[9] In order to identify a passive fit, the master cast used in this study was produced using a previously completed metal framework. However, a gap of 31.63 µm was still observed between the framework and abutment analogs. This gap can be explained by the micrometric tolerance inherent in the machining of the prosthodontic components and by the measurement method employed. Just 1 titanium screw was tightened to the framework, leading to amplification of the gap values.

A torque of 10 Ncm was used for tightening the gold screws. With a higher torque, there would have been a risk of screw fracture. The vertical discrepancy would have been reduced with a higher torque, and there inevitably would have been transfer of stresses to the implants and screws.[9]

Table 4 Comparison Among Pouring Techniques for Tapered Impression Copings

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Tukey groupings
1a	20	116.97	116.745	73.500	173.58	B
1b	20	65.69	69.215	47.285	89.425	A
1c	20	141.12	123.235	72.520	205.68	B

H = 11.716 with 2 degrees of freedom. (P = .003).

Table 5 Comparison Among Pouring Techniques for Impressions with Squared Transfers

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Tukey groupings
2a	20	57.84	59.905	44.715	84.390	B
2b	20	38.03	32.310	23.800	42.875	A
2c	20	74.19	72.010	53.410	101.09	B

H = 13.158 with 2 degrees of freedom (P = .001).

Table 6 Comparison Among Pouring Techniques for Impressions with Splinted Transfers

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Tukey groupings
3a	20	73.17	66.955	51.350	97.295	A
3b	20	82.47	73.220	46.435	101.595	A
3c	20	104.67	95.820	45.210	123.835	A

H = 1.572 with 2 degrees of freedom (P = .456).

Table 7 Comparison Between the Master Cast and Index

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Mann-Whitney groupings
Master cast	20	31.63	28.865	20.39	42.870	A
Index	20	27.07	26.705	19.03	31.975	A

T = 445 (P = .351).

Table 8 Comparison of All Impression Techniques Against Index

Group	n	Mean	Median	Percentile 25%	Percentile 75%	Dunn's groupings
Index	20	27.07	26.705	19.030	31.975	A
1a	20	116.97	116.745	73.500	173.580	B
1b	20	65.69	69.215	47.285	89.425	B
1c	20	141.12	123.235	72.520	205.680	B
2a	20	57.84	59.905	44.715	84.390	B
2b	20	38.03	32.310	23.800	42.875	A
2c	20	74.19	72.010	53.410	101.090	B
3a	20	73.17	66.955	51.350	97.295	B
3b	20	82.47	73.220	46.435	101.595	B
3c	20	104.67	95.820	45.210	123.835	B

H = 71.918 with 9 degrees of freedom. ($P \leq$ .001).

In 1994, Kallus and Bessing[35] developed a rating scale for evaluation of the fit of a framework. A prosthesis was seated on abutments and tightened with 1 gold screw in the most distal abutment on the left side. The discrepancy between the gold cylinder and the most distal abutment on the right side was given a rating using a 4-point scale: 0 = no visible discrepancy, 1 = slight discrepancy indicating a clear elevation of the framework with a gap less than 0.5 mm, 2 = a moderate discrepancy of approximately 0.5 to 1 mm, and 3 = a pronounced discrepancy with a gap of clearly more than 1 mm. If this classification had been used in this study, all of the results would have been 0 or 1, since the largest gap value measured for an analog was 327.08 μm. In cases where the fit was 0, a gap between the abutment and framework would have been detectable only microscopically.[25]

An ideal impression technique would require minimal time. It would be easy to use, inexpensive, and comfortable for the patient and, of course, would give the best results.[2] An advantage of the tapered coping technique is that an analog can be screwed into the tapered coping outside of the impression, which improves visualization of the adaptation between the 2 components. However, gap values observed with the indirect technique were greater than those observed with the direct technique. The inaccuracy seen with this technique seems to correlate with the addition of variables, such as distortion of the impression material during removal. The greater the divergence between analogs, the more imprecise the impression will be.[18] Since in this study the analogs were parallel to each other and perpendicular to the surface, this factor was minimized. The replacement of the tapered copings in the impression alters the position of the analog in the impression even before the pouring is accomplished. Spector et al[19] demonstrated air entrapment and incomplete seating of the impression tray, which may have impeded accurate placement of a transfer impression coping assembly. Weak union between the tapered coping and the impression material may have facilitated the movement of the analogs during the set expansion of the dental stone (group 1a = 116.97 μm; group 1c = 141.12 μm). However, the latex-tube pouring technique had a smaller influence on set expansion of the dental stone due to the smaller quantity of dental stone and more uniform distribution around the analog.

Satisfactory results were obtained with the use of the squared coping impression technique and the latex-tube pouring technique (group 2b = 38.03 μm). The gaps observed when the square coping technique was used were smaller than those observed with the splinted square coping technique. This may be explained by the smaller area for the forces of polyether impression material contraction (lineal dimensional alteration of –0.3%), which occurred only on the surfaces of the copings. However, with the splinted technique, these also acted on the resin bars, potentiating the negative effect of the contraction.

There seems to be no clinical advantage in splinting impression transfer copings with autopolymerizing acrylic resin, since polyether alone should simplify the impression procedures for osseointegrated implants and reduce the time required.[21] Polyether minimized the chance of accidental displacement of the direct impression coping when the abutment replicas were tightened.[1]

The pouring technique did not influence the accuracy of the stone casts when splinted square copings were used. Thus, the conventional pouring technique should be used, since it is an easier and faster technique. Since the splinted square coping technique showed no benefit over square copings alone, the extra time and complications involved in creating the resin splint could be considered unnecessary[2,14,21] unless this splinting is accomplished with the intention of making an index. The index (control) technique proved to be the best technique for reproducing the positioning of the implants (equaled only by the combination of squared impression copings and pouring using latex tubes).

It is possible for the squared coping to rotate inside the impression when the analog is torqued. For this reason, some authors indicate the union of the transfer copings with acrylic resin. In contrast, Hsu et al[20] and Herbst et al[14] reported that there is no need for such splinting. It is possible that a larger area was created for the performance of the polyether impression material during polymerization because of the union of the squared transfer copings with acrylic resin. Due to this polymerization contraction (–0.3%), there was a greater alteration of the inter-copings relationship in the mold after tray removal. Consequently, there was a verification of larger gaps when the measurements in the stone casts were obtained by this technique (a gap of 82.47 μm for splinted square copings with latex-tube pouring technique; a gap of 38.03 μm for square copings with latex-tube pouring technique).

The contraction of the impression material toward the tray walls[3,4] generates forces that alter the positioning of the impression copings. This may be one of the reasons why the index technique (which did not use impression material) presented better results than the impression technique with the splinted copings (27.07 μm for index group; 82.47 μm for splinted squared copings with latex-tube pouring technique).

Unlike De La Cruz et al,[23] who concluded that the dimensional accuracy provided by the verification jigs (Index) was not superior to standard impression procedures, the index technique was better than practically all of the techniques, only equaling the squared/latex technique (38.03 µm). It should be remembered that these 2 techniques were statistically similar to the master cast (31.63 µm).

Thus, using either of these 2 techniques, an accurate working cast is more likely to be made. Framework fabrication could then be carried out on one of these models. A clinician can instruct the laboratory to cast each unit separately and solder them using the master cast as an index. If the final casting fits the master cast, then a clinician should be confident that it will most likely fit a patient's mouth.[34] This would be of great advantage, since passive adaptation of the implant abutment to the framework is often difficult to achieve and to interpret in a clinical setting.[6]

Regarding pouring techniques, the best results were obtained with the latex-tube pouring technique, since this technique used a smaller quantity of dental stone evenly distributed around each analog, thus minimizing the setting expansion. Another possibility would be to use an ultra-low-expansion plaster (setting expansion of 0.02%).[36]

Hussaini and Wong[34] described a procedure that involved sectioning and rejoining the analogs; the union material used was impression plaster (setting expansion of 0.06%) instead of acrylic resin as in this study. Results demonstrated that the pouring technique in analogs joined with acrylic resin had a tendency to produce larger gap values. However, these gap values were statistically similar to the conventional pouring technique, possibly due to the fact that the union of the analogs with acrylic resin increases the area for the development of the setting expansion forces of the plaster (0.04 to 0.08% in 2 hours).

CONCLUSIONS

Under the conditions of this study, the following conclusions can be drawn:

1. The best impression technique was the squared copings technique.
2. The best pouring technique employed the latex tubes, with impressions made with either tapered or squared copings.
3. The pouring technique did not influence the accuracy of the stone casts when splinted squared impression copings were used.
4. The index technique, or the combination of squared copings with the latex-tube pouring technique, were the best methods for making implant-supported fixed restorations with dimensional accuracy.

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