In vitro comparison of master cast accuracy for single-tooth implant replacement

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Statement of problem. The inaccuracy in transferring the position of the hexagonal head of a single implant to the working cast can result in a final single tooth crown, which clinically may present occlusal and / or interproximal contacts that are different from those contacts on the master cast obtained by the technician.

Purpose. This in vitro study evaluated the accuracy of the master casts obtained using square pick-up impression copings for single-tooth replacement. Copings used were (1) copings as sold by the manufacturer, and (2) copings modified by sandblasting and coating with impression adhesive their roughened surfaces before final impression procedures.

Material and methods. A polymeric resin model with a standard single implant was used to simulate a clinical situation. A group of 20 impressions were made using nonmodified impression copings; a second group of 20 impressions were fabricated with modified copings. Master casts fabricated for both groups were analyzed to detect rotational position change of the hexagon on the implant replicas in the master casts in reference to the resin model.

Results. The rotational position changes of the hexagon on implant replicas were significantly less variable in the master casts obtained with the modified impression copings than in the master casts achieved with the nonprepared copings.

Conclusion. Improved precision of the impression was achieved when the adhesive-coated copings were used. (J Prosthet Dent 2000;83:562-6.)

CLINICAL IMPLICATIONS

This report suggests that sandblasting and coating the roughened surface of the impression copings before final impression procedures will enable the clinician to achieve a more accurate orientation of the implant replicas in the laboratory master casts in single-tooth implant restorations.

The transfer of the exact position and orientation of the implants to the working cast is particularly important in implant restorative procedures.[1-3] When a multiple abutment restoration is fabricated, the pick-up impression copings can be joined together with acrylic resin or composite to stabilize them within the impression material. Similar procedures are not applicable for single-tooth replacement, which may imply that minor movements of the impression coping retained inside the impression material can occur during all the procedural passages, leading to the master cast. As a result, the transfer of the exact position of the implant with its hexagonal head to the working cast may be tri-dimensionally inaccurate. This inaccuracy can lead to the fabrication of a final single tooth crown that, clinically, may present occlusal and / or interproximal contacts different from those achieved by the technician on the working casts.

Numerous reports have evaluated the importance of various clinical and laboratory steps in the elaboration of accurate master casts in regular crown and fixed partial denture procedures such as impression materials,[4-6] use of custom trays,[7,8] and use of adhesives in the impression tray.[9] In multiple abutment implant prosthodontics, many technical variations have been suggested to improve the accuracy of the final master casts. Carr[10] compared a direct and an indirect impression technique for a 5-implant model and concluded that the direct transfer method produced a more accu-

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rate cast. Others reported that splinting pick-up–type impression copings during the impression phase would yield better results.[11] Assif et al[12] reported that using acrylic resin to splint transfer copings in the impression material produced more accurate results than splinting the transfer copings directly to the acrylic resin custom tray or leaving the transfer copings unsplinted. Other investigators did not find statistical differences between splinting and nonsplinting techniques.[13,14]

Various studies of single-implant restorations have reported on their predictability[15-21]; however, few studies have evaluated impression procedures in single-implant reconstruction. Schmitt et al[22] measured the accuracy of 2 impression techniques recommended by Noblepharma to be used with their CeraOne single-tooth implant restoration. The first technique involved luting the impression transfer coping to the impression tray with autopolymerizing acrylic resin. The second technique left the transfer coping freestanding in the impression material. A jig was fabricated and used to record the spatial relations of the impressions and the transfer copings in reference to the jig. The results of this study indicated that the more accurate technique was to transfer the impression coping without luting it to the impression tray. Jacobson et al[23] advocated the use of a positioning jig to detect any eventual misplacing of the implant analog hexagon in the master cast and correct its position. However, this method would ultimately require complex and time-consuming intraoral adjustments.

A simple procedure that includes roughening of the external surface of the pick-up impression coping and applying an adhesive coating on the roughened surface may be applied in single-tooth implant cases to create a firmer connection between the impression coping and impression material. Theoretically, this would decrease the amount of micromovements of the coping inside the impression material during all passages from impression making to pouring and lead to the fabrication of a master cast replicating more accurately the clinical situation.

The purpose of this in vitro study was to evaluate the positional differences between a polymeric resin model simulating the clinical situation of a maxillary single-tooth implant and 2 groups of master casts replicating the reference model, 1 group using nonmodified UCLA-type square impression copings (pick-up type) and the other using the same type of impression copings previously sandblasted and coated with impression adhesive.

MATERIAL AND METHODS

A polymeric resin model (Blue Star Type E, Breitschmid, Kriens, Switzerland) of a maxillary arch with a standard-threaded 3.75 × 10-mm implant (3i, Implant Innovations, Inc, Palm Beach Gardens, Fla.), positioned in the second right premolar edentulous site with a 3-mm deep transmucosal canal was used to simulate a clinical situation. The first molar distal to the implant and the first premolar mesial to the implant were cut in a buccopalatal direction using a diamond disc Ø75X0.2 mounted on Girrbach Cutman-100 machine (Girrbach Dental GmbH, Pforzheim, Germany) to obtain 2 reference planes (Fig. 1).

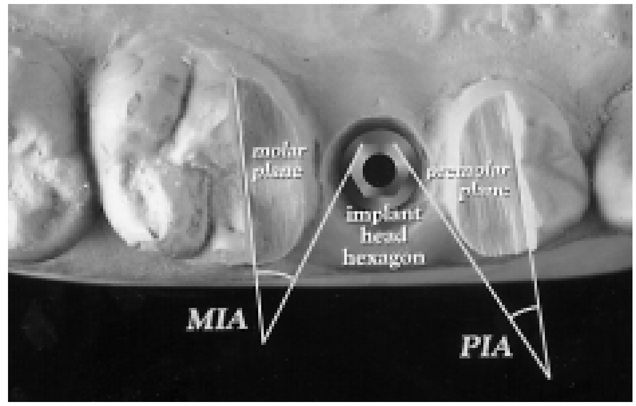

Fig. 1. Representation of resin model showing reference molar and premolar planes and angles formed by molar plane and distopalatal side of implant hexagon (*MIA*) and premolar plane and mesiopalatal side of implant hexagon (*PIA*).

Forty identical 2-mm thick custom impression trays were made with Palatray LC resin (Kulzer Heraeus, Wehrheim, Germany). Impression material was mixed according to the manufacturer's instructions. The trays were fabricated 24 hours before impressions were made. The impression trays had a window to allow access for the copings screws and were previously coated with the Impregum polyether adhesive (ESPE Dental-Medizin GmbH & Co KG, Seefeld, Germany) 1 hour before the impressions were made. Before every impression procedure, an implant square impression pick-up–type coping (3i, Implant Innovations, Inc) was secured to the implant in the resin model using a torque wrench calibrated at 10 N·cm (Torqometer, Snap-on Tools Corp, Kenosha, Wis.). All 40 impressions were made using an equal amount of polyether material (Impregum Penta, ESPE). The impression material was machine-mixed (Pentamix, ESPE) and part of it meticulously syringed all around the impression coping to ensure complete coverage of the coping itself. The remaining impression material was used to load the impression tray.

Two groups of 20 impressions each were made; group A with nonmodified square impression copings (Fig. 2), and group B with square impression copings sandblasted with a Dentalfarm Base 3 machine (Dentalfarm, Torino, Italy) using a clean 50 μm aluminum oxide abrasive powder at 2.5 atmosphere pressure to

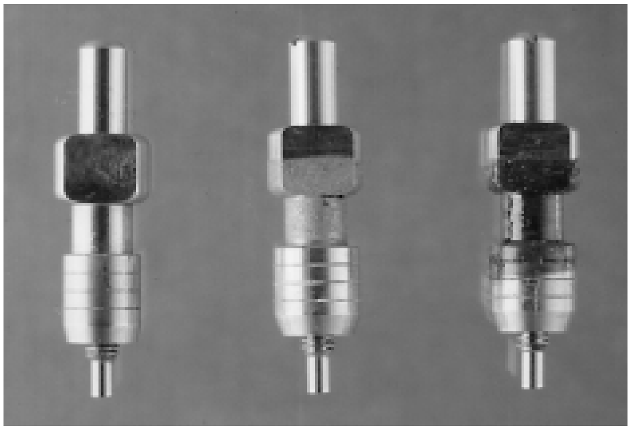

Fig. 2. From left to right, transfer copings as-received, sandblasted, and coated with impression adhesive.

roughen their external surfaces at a supragingival level, and then coated with the Impregum polyether adhesive (Fig. 2).

Five minutes were allowed for the setting of the impression material after which the coping screws were unscrewed and the impressions removed from the resin model. Twenty-four hours later, an implant replica (3i, Implant Innovations, Inc) was screwed on top of the impression coping and the impression poured with a type IV stone (New Fujirock, GC Corp, Tokyo, Japan), following manufacturer's instructions. All clinical and laboratory procedures were performed by the same operator.

Fig. 3. Nikon Profile projector and master cast specimen.

Measurements and statistical analysis

The 2 angles formed by the molar plane and the distopalatal side of the implant hexagon (MIA) and the premolar plane and the mesiopalatal side of the implant hexagon (PIA) in the resin model, and the 40 master casts in groups A and B (Fig. 1) were measured with a Nikon Profile projector (model V-12, no. 123222, magnification ×10, Nikon, Nippon Kogaku, Japan). The angles measured on the reference resin model were equal to 39 degrees 22 minutes and 29 degrees 46 minutes. The profile projector (Fig. 3), equipped with a screen with horizontal and vertical reference lines, has a movable table that allows one to position the object being studied. A light source allows the projection of a magnified image of the object onto the screen in the form of a shadow so that the sharp edges of the projected silhouetted form become the reference points of measurement. All measurements were recorded by the same blinded operator. Intraoperator variability was assessed using 10 repeated measurements of the angles MIA and PIA in 1 randomly selected master cast in each of the groups A and B.

Rotational movements of the impression copings inside the impression material in groups A and B were assumed to result in angular variations between the resin model and the stone master casts. Therefore, the differences in minutes between the angles MIA and PIA measured on the reference resin model and the equivalent angles measured on the 40 master casts were analyzed using the Mann-Whitney U test and the 2-sample Kolmogorov-Smirnov test.

RESULTS

Relative to intraoperator variability, standard deviations of the 10 repeated measurements were 5.29 minutes and 4.73 minutes for the angles MIA and PIA, respectively, in the master cast selected in group A; the corresponding figures were 3.90 minutes and 4.27 minutes, respectively, for the group B master cast. These small standard deviations indicate the acceptable reliability of the measurement method.

A mean angular variation of 35.60 ± 132.16 minutes was found for the angle MIA and 36.30 ± 32.79 minutes for the angle PIA in group A, in which adhesive was not used. For group B, in which modified impression copings were used, the corresponding figures were 0.60 ± 36.33 minutes for the angle MIA and

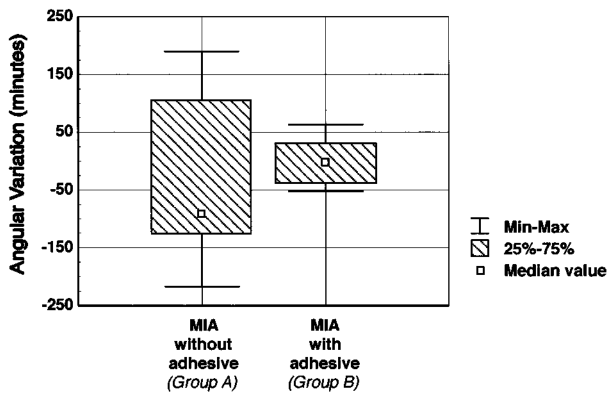

Fig. 4. Box whiskers plot comparing variations of angle MIA between groups A and B. Median represents 50th percentile of sample. Top and bottom of boxes show 75th and 25th percentiles, whereas top and bottom of whiskers depict maximum and minimum values. Large interquartile range in group A in which adhesive was not used.

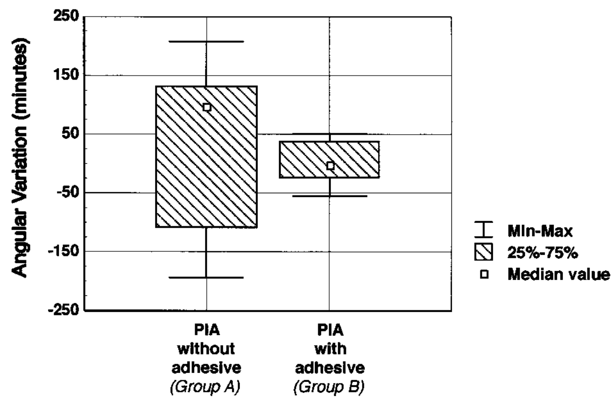

Fig. 5. Box whiskers plot comparing variations of angle PIA between groups A and B. Limited spread of data around median value of angle PIA in group B reflects improved precision of master casts obtained with modified impression copings.

0.10 ± 34.38 minutes for the angle PIA. Statistical analysis revealed no significant differences between the medians of the 2 groups, but significantly less measurement variability to the advantage of the adhesive group ($P<.01$). Box whiskers plots, illustrated in Figures 4 and 5, depict the scatter of the distributions in groups A and B. Group B exhibited a significantly improved precision when compared with group A.

DISCUSSION

The purpose of this study was to evaluate the usefulness of roughening the external surfaces of UCLA-type abutment square impression copings (pick-up type) and applying an impression adhesive coating on the roughened surfaces before the final impression procedure in case of the single-tooth replacement. Although the angular variations of the angles MIA and PIA were not significantly different between groups A and B, comparison of the variances revealed that coping modification yielded more precise master casts in which the spatial orientation of the hexagon head of the implant replica corresponded closely to the hypothetical intraoral spatial position of the implant head.

Our study suggests the coating of the impression copings with adhesive in the impression phase for single-implant restorations to improve the accuracy of the final master casts. The intimate contact between the impression material and impression copings that resulted from the application of impression adhesive seems to reduce the freedom of rotational movement of the impression copings inside the impression material during the clinical and laboratory phases. As a consequence, the laboratory technician is able to fabricate a restoration that will ultimately require less intraoral modifications, especially adjustments of interproximal contacts and occlusal adjustments. It is reasonable to suggest that the results of our study applied to situations of single-tooth implant replacement may be extended to include multiple abutment implant restorations.

Both groups included in this report yielded small mean angular variations (–35.60 ± 132.16 minutes for MIA angle, 36.30 ± 132.79 minutes for PIA angle in group A; 0.60 ± 36.33 minutes for MIA angle, 0.10 ± 34.38 minutes for PIA angle in group B) relative to the reference resin model. When comparing ranges, the maximum angular variation obtained with adhesive was 1 degrees 0.2 minutes, whereas the corresponding figure was 3 degrees 38 minutes without adhesive. Using different measurement parameters, Schmitt et al[22] reported a displacement of 0.275 mm in the horizontal plane for transfer copings luted to the impression tray, and 0.094 mm for nonluted impressions. The significance of such discrepancies may not be substantial in clinical situations. However, it is the authors' clinical experience that less intraoral adjustments of interproximal contacts and occlusal modifications are needed when the impression is obtained using modified transfer copings.

Measurement of angular variations is a delicate procedure with various sources of errors such as those inherent to the present measuring technique, intraoperator variability, and distortion of the molar and premolar planes in the master casts. However, the statistical analysis used in our investigation showed that the large standard deviations relative to the angles MIA and PIA found in group A reflect the wide variability in the precision of master casts obtained with as-received impression copings than are due to poor precision of the measurements.

CONCLUSIONS

Within the limitation of this in vitro study, the following conclusions were drawn:

1. The master casts obtained with the roughened and adhesive-coated impression copings showed a significantly lower amount of rotational movement than the master casts achieved with the nonmodified impression copings ($P<.01$) relative to the position of the hexagon head of the implant on the reference resin model.

2. The elaboration of a master cast in which the spatial orientation of the hexagon head of the implant replica accurately reproduce the intraoral position of the hexagon head of the implant resulted in less time-consuming chairside modifications and adjustments.

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