Master Cast Accuracy in Single-Tooth Implant Replacement Cases: An In Vitro Comparison. A Technical Note

Paolo Vigolo, Dr Odont, MScD[1]/Fulvio Fonzi, CDT[2]/Zeina Majzoub, DCD, DMD, MScD[3]/
Giampiero Cordioli, MD, DDS[4]

Purpose: *This in vitro study evaluated the accuracy of master casts obtained by using (1) copings modified by sandblasting and coating their roughened surfaces with impression adhesive before final impression procedures and (2) gold machined UCLA abutments as impression copings in final impression procedures for single-tooth implant replacement cases.* ***Materials 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 square impression copings sandblasted to roughen their external surfaces at a supragingival level and then coated with Impregum polyether adhesive; a second group of 20 impressions were made using gold machined UCLA abutments as impression copings. The castable part of the UCLA abutments was secured with resin to the gold machined section of the UCLA abutment to prevent movement of the castable part itself on the gold machined portion during the impression procedures; the castable portion of the UCLA was also coated with the Impregum polyether adhesive to improve the stability of the gold machined UCLA abutment inside the impression material. Master casts fabricated for both groups were analyzed to detect rotational position change of the hexagon on the implant replicas in the master casts with 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 using gold machined UCLA abutments as impression copings than in the master casts achieved with the roughened square impression copings.* ***Discussion:*** *Improved precision of the impression was achieved when the gold machined UCLA abutments were used as impression copings.* ***Conclusion:*** *This report suggests that using gold machined UCLA abutments as impression copings in the final impression procedures can enable the clinician to achieve a more accurate orientation of the implant replicas in the laboratory master casts for single-tooth implant replacement cases.* INT J ORAL MAXILLOFAC IMPLANTS 2005;20:455–460

Key words: *dental implants, implant abutments, master casts, single tooth replacement*

Transfer of the exact position and orientation of implants to the working cast is particularly important in implant restorative procedures.[1–3] When a multiple-abutment restoration is fabricated, the pickup 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 transfers which lead to the master cast. As a result, 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 definitive single-tooth crown that, clinically, may present occlusal and/or interproximal contacts dissimilar from those achieved by the technician on the working casts.

[1]Assistant Professor, Department of Clinical Odontostomatology, University of Padova, Institute of Clinical Dentistry, Padova, Italy.
[2]Certified Dental Technician, Private Practice, Vicenza, Italy.
[3]Professor, Department of Periodontology, Lebanese University, School of Dentistry, Beirut, Lebanon.
[4]Professor and Chairman, Department of Clinical Odontostomatology, University of Padova, Institute of Clinical Dentistry, Padova, Italy.

Correspondence to: Dr Paolo Vigolo, Via Vecchia Ferriera, 13, 36100 Vicenza, Italy. Fax: +1139 444 964545.
E-mail: paolovigolo@virgilio.it

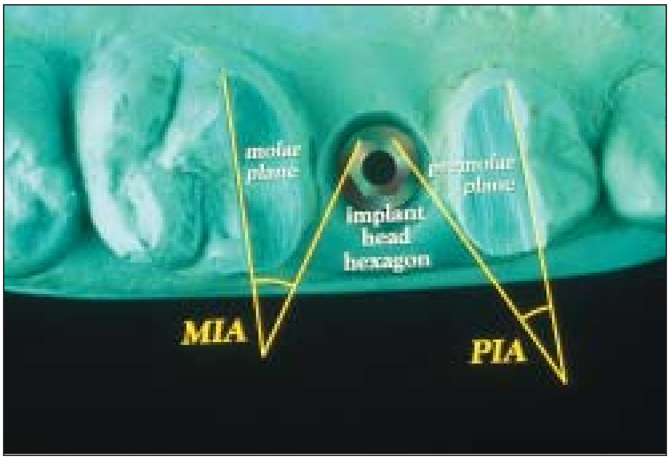

Fig 1 Representation of resin model showing reference molar and premolar planes, the angle formed by the molar plane and the distopalatal side of the implant hexagon, (MIA) and the angle formed by the premolar plane and the mesiopalatal side of the implant hexagon (PIA).

Numerous reports have evaluated the importance of various factors and clinical and laboratory steps in the elaboration of accurate master casts for 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 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 accurate cast. Others reported that splinting pickup-type impression copings during the impression phase yielded better results.[11] Assif and coworkers[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 and colleagues[22] measured the accuracy of 2 impression techniques recommended by Nobel Biocare (Göteborg, Sweden) 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. The results of this study indicated that the more accurate technique was to transfer the impression coping to the impression tray without luting it. De La Cruz and associates[23] reported that the accuracy provided by verification jigs was not significantly superior to standard impression procedures. Open-tray impressions showed significantly greater inaccuracy in the vertical plane. Daoudi and colleagues[24] investigated the accuracy of 4 impression procedures for single-tooth implants using 2 impression techniques and 2 different materials. The results showed greater variations in analog position with the repositioning impression technique than with the pickup technique. The rotational errors were large enough to be of clinical concern. No significant differences were found between polyvinyl siloxane and polyether impression materials for 2 tested types of impression techniques.

Jacobson and coworkers[25] advocated the use of a positioning jig to detect any eventual misplacement 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. Daoudi and colleagues[26] investigated the accuracy of the repositioning impression technique at the implant level using vinyl polysiloxane impression material. Three groups each of 10 senior dentists, postgraduate students, and technicians were asked to use this technique to record the position of a single implant in a master model. The Reflex microscope (Reflex, Somerset, United Kingdom) was used to measure variations between the resulting casts and the master model. A significant difference between the casts and the master model in the x and y axes ($P < .01$) was recorded. Alarming inclinational and rotational errors for the implant analog position were measured with all groups of operators. Similar distortion in the z axis was recorded.

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

Fig 2a Square impression copings sandblasted and then coated with Impregum polyether adhesive (group A).

Fig 2b Gold machined UCLA abutments modified as described (group B).

single-tooth implant and 2 groups of master casts replicating the reference model: 1 group using UCLA-type square impression copings (pickup type) sandblasted and coated with impression adhesive, and the other using gold machined UCLA abutments (3i/Implant Innovations, Palm Beach Gardens, FL) as impression copings.

MATERIALS 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), positioned in the right second premolar 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 disk 22 mm in diameter (Komet 911 H; Gebr Brasseler, Lemgo, Germany) and mounted on a Girrbach Cutman 100 machine (Girrbach Dental, Pforzheim, Germany) to obtain 2 reference planes (Fig 1).

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 impression trays had a window to allow access for the coping screws and had been coated with the Impregum polyether adhesive (ESPE Dental, Seefeld, Germany). Two groups of 20 impressions each were made: for group A, square impression copings (3i/Implant Innovations) with roughened surfaces were used, and for group B, gold machined UCLA abutments were used (3i/Implant Innovations). The square impression copings used for group A were sandblasted with a Dentalfarm Base 3 machine (Dentalfarm, Turin, Italy) using a clean 50-μm aluminum oxide abrasive powder at 2.5 atm to roughen their external surfaces at a supragingival level and then coated with the Impregum polyether adhesive as described in a previous article.[27] The castable part of the UCLA abutments was secured with resin (Pattern Resin LS, GC Corporation, Tokyo, Japan) to the gold machined portion of the UCLA 24 hours before impressions were made to prevent any movement of the castable part itself on the gold machined portion during the impression procedures. The castable portion of the UCLA was also coated with the Impregum polyether adhesive to improve the stability of the gold machined UCLA abutment inside the impression material (Figs 2a and 2b). Both square impression copings and gold machined UCLA abutments were secured to the implant in the resin model using long laboratory screws (3i/Implant Innovations) fastened with a torque wrench calibrated at 10 Ncm (Torqometer, Snap-on Tools, Kenosha, WI).

All 40 impressions were made using an equal amount of polyether material (Impregum Penta, ESPE Dental). The impression material was machine-mixed (Pentamix, ESPE Dental), and part of it was meticulously syringed around the impression coping to ensure complete coverage of the coping itself. The remaining impression material was used to load the impression tray. Five minutes were allowed for the setting of the impression material, after which the screws were released and the impressions removed from the resin model. An implant replica (3i/Implant Innovations) was screwed on top of the impression coping and of the gold machined UCLA abutments; the impressions were poured with a type IV stone (New Fujirock, GC Corporation), following manufacturer's instructions. All clinical and laboratory procedures were performed by the same operator.

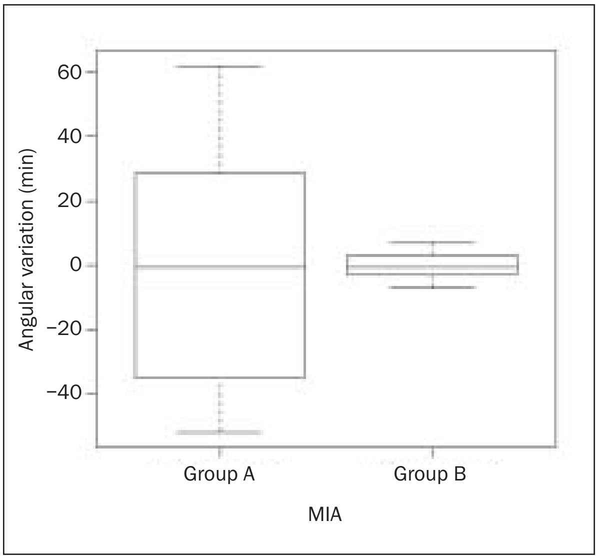

Fig 3 Box whiskers plot comparing variation of angle MIA between groups A and B. Top and bottom of boxes indicate 25th and 75th percentiles; the tops and bottoms of the whiskers depict maximum and minimum values. The horizontal line in each box represents the median value. A large interquartile range was seen in group A.

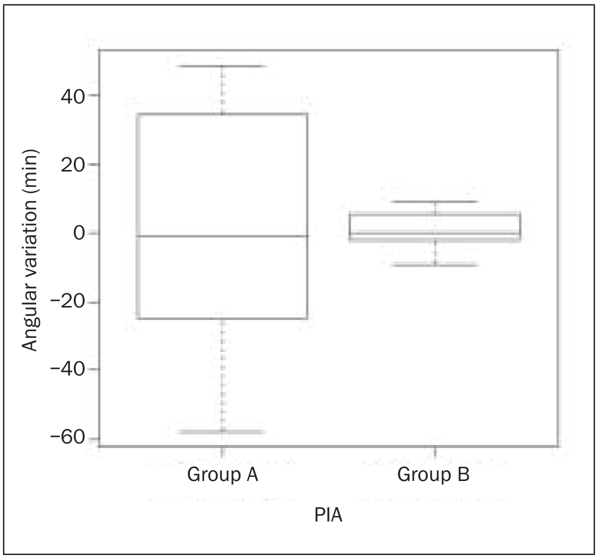

Fig 4 Box whiskers plot comparing variation of angle PIA between groups A and B. The limited spread of data around the median value of angle PIA in group B reflects the superior precision of master casts obtained using gold machined UCLA abutments as impression copings.

Measurements and Statistical Analysis

The angle formed by the molar plane and the distopalatal side of the implant hexagon (MIA) in the resin model, the angle formed by the premolar plane and the mesiopalatal side of the implant hexagon (PIA), and the 40 master casts (Fig 1) were measured with a Nikon Profile projector (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, 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 Shapiro-Wilk test, the F test and 1-way analysis of variance (ANOVA) weighted for unequal variances ($P \leqslant .05$ was considered statistically significant).

RESULTS

For the master cast selected in group A (square impression copings sandblasted and then coated with the Impregum polyether adhesive), standard deviations (SDs) of the 10 repeated measurements were 3.90 minutes and 4.27 minutes for angles MIA and PIA, respectively; for the master cast selected in group B (gold machined UCLA abutments) the corresponding values were 1.51 minutes and 0.97 minutes.

These SDs were rather small and indicated that intraoperator variability was limited, especially in group B. Indeed, the reliability of the measurement method had already been accepted in a previous article.[27]

The Shapiro-Wilk test was used to check the normality of variation of angles MIA and PIA in groups A and B; normality was accepted. The smallest P value was .19. In group A, the mean values were 0.6 minutes for MIA and 0.1 minutes for PIA; in group B, the corresponding figures were –0.1 minutes for MIA and 1.1 minutes for PIA.

In group A, the SDs were 36.34 minutes for MIA and 34.39 minutes for PIA; in group B, they were 4.36

minutes for MIA and 5.56 minutes for PIA. In group A, the resulting confidence limits (95% level) were –16.40 and 17.60 for MIA and –15.99 and 16.19 for PIA; in group B, they were –2.14 and 1.94 for MIA and –1.50 and 3.70 for PIA.

Figures 3 and 4 show that variability was much higher in group A for both MIA and PIA. Therefore, the F test was used to compare variances between group A and B. For both MIA and PIA, variances were statistically significant ($P < .001$). The classical 1-way ANOVA is known to be misleading when the normal populations have different variances. To overcome this, the 1-way ANOVA was weighted for unequal variances. It revealed no significant differences between the 2 methods for either MIA or PIA ($P = .93$ and $P = .89$, respectively). In any case, group B exhibited a significantly better precision compared with group A.

DISCUSSION

The purpose of this study was to evaluate the usefulness of using gold machined UCLA abutments as impression copings in the final impression procedure for single-tooth replacements. 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 using gold machined UCLA abutments as impression copings 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.

This study suggests the use of zero rotation gold machined UCLA abutments as impression copings in the impression phase for single-implant restorations may improve the accuracy of the final master casts. The gold standard zero rotation features of the gold machined UCLA abutments seems to reduce the risk of rotational movement of the UCLA abutment used as impression copings on the implant hexagon 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 fewer intraoral modifications, especially adjustments of interproximal contacts and occlusal adjustments. It is reasonable to suggest that the results of the 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. The significance of such discrepancies may not be substantial in clinical situations. However, it is the authors' clinical experience that fewer intraoral adjustments of interproximal contacts and occlusal modifications are needed when the impression is obtained using gold machined UCLA abutments as impression copings.

CONCLUSION

Within the limitation of this in vitro study, the following conclusion was drawn: The master casts obtained with the gold machined UCLA abutments as impression copings, as described herein, showed less variable rotational position changes of the hexagon on implant replicas than the master casts achieved with the roughened and adhesive-coated impression copings relative to the position of the hexagon head of the implant on the reference resin model.

ACKNOWLEDGMENTS

The authors acknowledge the help given by Dr Claudia Furlan in assisting with the statistical analysis. They also express special thanks to the Centro di Odontoiatria Riabilitativa (COR) of Vicenza, Italy, for its generous support.

REFERENCES

1. Zarb GA, Jansson TP. Laboratory procedures and protocol. In: Brånemark P-I, Zarb GA, Albrektsson T (eds). Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago: Quintessence, 1985:293–315.
2. Wee AG, Schneider RL, Aquilino SA, Huff TL, Lindquist TJ, Williamson DL. Evaluation of the accuracy of solid implant casts. J Prosthodont 1998;3:161–169.
3. Vigolo P, Millstein PL. Evaluation of master cast techniques for multiple abutment implant prostheses. Int J Oral Maxillofac Implants 1993;8:439–446.
4. Tjan AH, Whang SB, Tjan AH, Sarkissian R. Clinically oriented evaluation of the accuracy of commonly used impression materials. J Prosthet Dent 1986;56:4–8.
5. Lin CC, Ziebert GJ, Donegan SJ, Dhuru VB. Accuracy of impression materials for complete-arch fixed partial dentures. J Prosthet Dent 1988;59:288–291.
6. Dounis GS, Ziebert GJ, Dounis KS. A comparison of impression materials for complete-arch fixed partial dentures. J Prosthet Dent 1991;65:165–169.
7. Rueda LJ, Sy-Muñoz JT, Naylor WP, Goodacre CJ, Swartz ML. The effect of using custom or stock trays on the accuracy of gypsum casts. Int J Prosthodont 1996;9:367–373.
8. Gordon GE, Johnson GH, Drennon DG. The effect of tray selection on the accuracy of elastomeric impression materials. J Prosthet Dent 1990;63:12–15.
9. Ciesco JN, Malone WF, Sandrik JL, Mazur B. Comparison of elastomeric impression materials used in fixed prosthodontics. J Prosthet Dent 1981;45:89–94.
10. Carr AB. A comparison of impression techniques for a five-implant mandibular model. Int J Oral Maxillofac Implants 1991;6:448–455.

11. Assif D, Fenton A, Zarb G, Schmitt A. Comparative accuracy of implant impression procedures. Int J Periodont Restor Dent 1992;12:112–121.
12. Assif D, Marshak B, Schmidt A. Accuracy of implant impression techniques. Int J Oral Maxillofac Implants 1996;11:216–222.
13. Spector MR, Donovan TE, Nicholls JI. An evaluation of impression techniques for osseointegrated implants. J Prosthet Dent 1990;63:444–447.
14. Humphries RM, Yaman P, Bloem TJ. The accuracy of implant master casts constructed from transfer impressions. Int J Oral Maxillofac Implants 1990;5:331–336.
15. Ekfeldt A, Carlsson GE, Börjesson G. Clinical evaluation of single-tooth restorations supported by osseointegrated implants: A retrospective study. Int J Oral Maxillofac Implants 1994;9:179–183.
16. Cordioli G, Castagna S, Consolati E. Single-tooth implant rehabilitation: A retrospective study of 67 implants. Int J Prosthodont 1994;7:525–531.
17. Haas R, Mensdorff-Pouilly N, Mailath G, Watzek G. Brånemark single tooth implants: A preliminary report of 76 implants. J Prosthet Dent 1995;73:274–279.
18. Avivi-Arber L, Zarb GA. Clinical effectiveness of implant-supported single-tooth replacement: The Toronto study. Int J Oral Maxillofac Implants 1996;11:311–321.
19. McMillan AS, Allen PF, Bin-Ismail I. A retrospective multicenter evaluation of single tooth implant experience at three centers in the United Kingdom. J Prosthet Dent 1998;79:410–414.
20. Schmitt A, Zarb GA. The longitudinal clinical effectiveness of osseointegrated dental implants for single-tooth replacement. Int J Prosthodont 1993;6:197–202.
21. Jemt T, Lekholm U, Grondahl K. 3-year follow-up study of early single implant restoration ad modum Brånemark. Int J Periodontics Restorative Dent 1990;10:340–349.
22. Schmitt JK, Adrian ED, Gardner FM, Gaston ML. A comparison of impression techniques for the CeraOne abutment. J Prosthodont 1994;3:145–148.
23. De La Cruz JE, Funkenbusch PD, Ercoli C, Moss ME, Graser GN, Tallents RH. Verification jig for implant-supported prostheses: A comparison of standard impressions with verification jigs made of different materials. J Prosthet Dent 2002;88:329–336.
24. Daoudi MF, Setchell DJ, Searson LJ. A laboratory investigation of the accuracy of two impression techniques for single-tooth implants. Int J Prosthodont 2001;14:152–158.
25. Jacobson Z, Peterson T, Kim WD. Positioning jig for implant abutments: Procedures and clinical applications. J Prosthet Dent 1996;75:435–439.
26. Daoudi MF, Setchell DJ, Searson LJ. A laboratory investigation of the accuracy of the repositioning impression coping technique at the implant level for single-tooth implants. Eur J Prosthodont Restor Dent 2003;11:23–28.
27. Vigolo P, Majzoub Z, Cordioli GP. In vitro comparison of master cast accuracy for single-tooth implant replacement. J Prosthet Dent 2000;83:562–566.