Implant Cast Accuracy as a Function of Impression Techniques and Impression Material Viscosity

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Purpose: *The aim of this study was to compare implant cast accuracy as a function of impression technique, closed tray impressions using indirect, metal impression copings at the implant level or direct, plastic impression caps at the abutment level, and impression material viscosity combinations.* ***Materials and Methods:*** *A stainless steel master model with three implant replicas was utilized to produce Type IV stone casts. Master model impressions were made using closed trays at the implant level with screw-on metal impression copings (indirect/implant level) or at the abutment level with snap-on plastic impression caps (direct/abutment level). With both techniques, either medium-body or heavy-body polyether impression material was syringed around the implant impression coping or abutment impression cap with medium body material in a custom tray. Twenty casts were produced with 5 casts in each test group. A measuring microscope (0.001 mm accuracy) was used to measure cast inter-implant or inter-abutment distances. Cast accuracy was calculated based on the percent difference of the measurements as compared to the master model.* ***Results:*** *A repeated measures 2-factor ANOVA (α = .05) indicated no significant difference in cast accuracy as a function of impression viscosity. However, cast accuracy was significantly different between casts made with indirect/implant level versus direct/abutment level impressions. With the plastic impression caps, the cast inter-abutment distances were larger than the master model, with mean percent differences of 0.19% to 0.24% across the 3 measurement sites. In contrast, with the metal impression coping impressions, the cast inter-implant distances were almost equal to or slightly smaller than the master model, with mean percent differences −0.06% to 0.02%.* ***Conclusions:*** *Impression material viscosity does not appear to be a critical factor for implant cast accuracy. However, casts made with indirect, metal impression copings might be more accurate than casts made with direct, plastic impression caps. This could be an especially important factor with casts used to fabricate multiple-implant restorations.* INT J ORAL MAXILLOFAC IMPLANTS 2008;23:669–674

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Making accurate impressions is an essential factor in successful implant restorative treatment. Early procedural guidelines recommended the use of an open tray/direct technique with impression copings splinted with methacrylate-based resin material.[1]

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However, the direct-splinted technique, which has been reported to have greater accuracy,[2–6] also has inherent problems, such as potential distortion related to polymerization shrinkage of the splinting material.[7] Furthermore, the open tray impression often cannot be used in the posterior arch, because the patient cannot open adequately to provide screwdriver access to the impression coping screws.

As a result, closed tray/indirect impressions[8–10] are being used with increasing frequency.[11] While this impression approach is much simpler, there is also the potential for impression inaccuracy.[8] For example, because the impression copings are retained on the implant or abutment upon impression removal, the copings must be removed and accurately repositioned within the respective impression. To mitigate this issue, snap-on plastic impression caps have been introduced.[11–14] With this method, the impression

Fig 1 Master metal model with implant replicas (10 mm apart).

cap is picked up in the impression, providing a direct impression technique without the open tray. Even with the impression cap pickup, there is still the potential for impression distortion as the implant or abutment replica is attached to the cap within the set impression.

Although the impression procedure is an important element of impression accuracy, the impression material itself is another factor related to final cast accuracy. With the increased use of the closed tray/indirect or direct impression procedure, it has been speculated that a more rigid impression material would facilitate the repositioning of the impression coping or abutment replica into the impression because there would be less potential for impression material distortion during positioning.[10] Based on this rationale, one company[15] is marketing an impression material specifically for implant impressions; the marketing information purports that the material sets more rigidly than most heavy-body impression materials and as a result will provide increased resistance to flexure and distortion with coping/replica placement. However, the disadvantage with rigid impression material is the potentially difficult impression removal from the mouth due to the high stiffness of the set material.[16,17] Thus, it might be more practical to use a medium-body material in the tray to prevent tray removal problems and to use the heavy-body material only around the impression copings or caps to realize the potential benefits of the stiffer material where it is needed to reduce potential distortion with impression coping or abutment replica placement.

Therefore, the purpose of the current investigation was to compare implant impression accuracy as a function of impression technique and impression material viscosity combinations. Closed tray impressions using a direct technique (metal impression coping at the implant level) and indirect technique (plastic impression cap at the abutment level) were made using heavy or medium-body material around the impression copings/caps in conjunction with medium-body material in the impression tray. The null hypothesis was that implant cast accuracy would not vary significantly due to impression technique and impression material viscosity.

MATERIALS AND METHODS

Impression Procedures, Cast Production Protocol

A custom-made stainless steel master model (University of Missouri–Kansas City Machine Shop) with 3 stainless steel implant analogs/replicas (NobelReplace, regular platform [RP, 4.3 mm], internal connection; Nobel Biocare, Göteborg, Sweden) in a triangular arrangement 10 mm apart (Fig 1) was used. The implant replicas were stabilized in the model with a low-fusing metal (Metspec 281, MCP Metalspecialities, Fairfield, CT).

Impressions of the master model were made with spaced custom trays (Triad light-polymerized resin; Dentsply, York, PA) with stops on the model base. Ten closed tray indirect/implant-level impressions were made using polyether impression material (PE, Impregum Penta Soft; 3M ESPE; St Paul, MN) and metal impression copings (NobelReplace, RP, internal connection; Nobel Biocare) on the implant replicas (Figs 2a and b). The impressions were made with heavy- or medium-body material syringed around the copings and medium-body material placed in the custom trays with PE tray adhesive (3M ESPE). Five impressions were made with each viscosity combination. Using the elastomeric impression material specification (ADA/ANSI[19]) protocol as a guide, the model with the loaded impression tray was transferred into a water bath maintained at 32 ± 2°C to simulate impression material polymerization in the oral environment.[18]

Upon impression material setting, 3 minutes longer than manufacturer's recommended minimal removal time (as indicated in the specification), the impression was removed from the model. After removing the copings from the model, implant replicas (NobelReplace; RP, internal connection, Nobel Biocare) were attached to the impression copings prior to repositioning within their respective impression site. The impressions with inserted coping/replicas were poured with vacuum-mixed type IV dental stone (Fig 2c; Resin Rock; Whip Mix Corp; Lexington, KY).

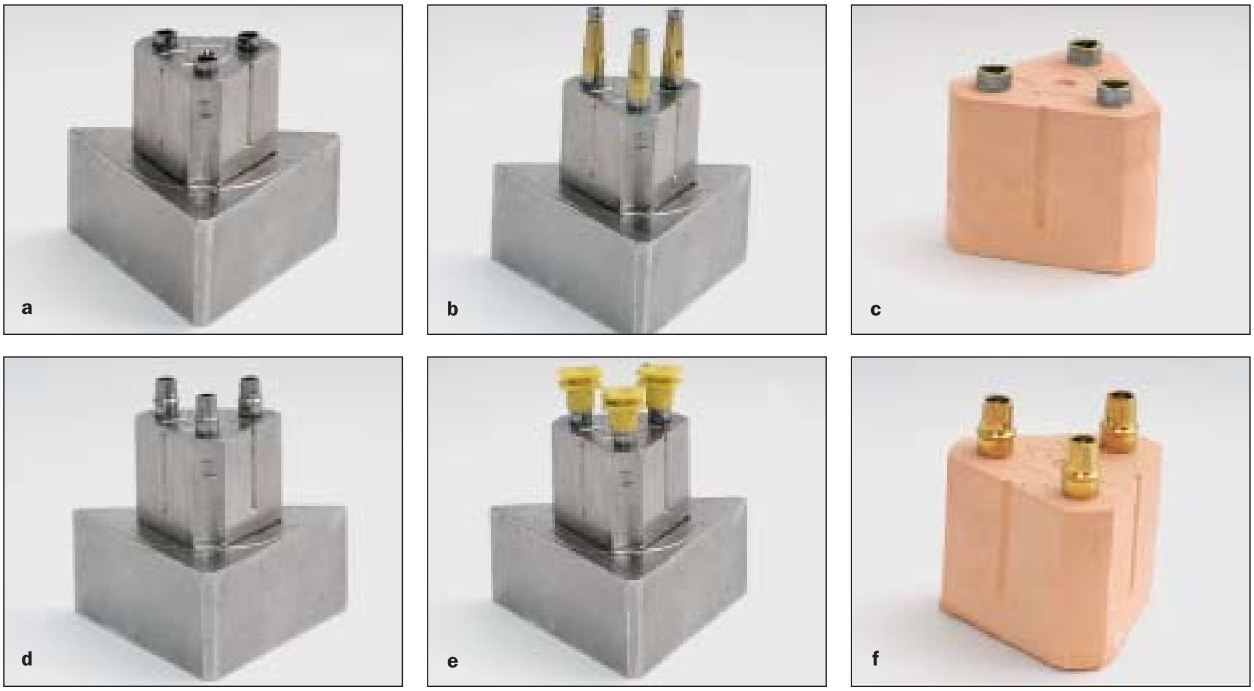

Fig 2 *(a)* Master model with implant replicas. *(b)* Master model with implant-level metal impression copings. *(c)* Cast with implant replicas. *(d)* Master model with abutment replicas. *(e)* Master model with abutment-level plastic impression caps. *(f)* Cast with abutment replicas.

Ten additional impressions were made of the master model using the same methodology as already described except instead of impressions made at the implant level with metal impression copings, Snap-style abutments (RP, internal connection; Nobel Biocare AB) were placed on the master model implant replicas, Fig 2d, (direct/abutment level). Before making each impression, a Snappy impression cap (Nobel Biocare) was placed on each abutment (Fig 2e). Prior to pouring each impression with type IV stone, a Snappy abutment replica was positioned within each picked-up impression cap.

Measurement Protocol and Statistical Analyses

With the indirect/implant level impression, the interimplant distance on the model were initially measured. This entailed measuring between implants 1 and 2 (site 1), 2 and 3 (site 2) and 1 and 3 (site 3) with a measuring microscope (Model W122, Gaertner Scientific, Skokie, IL) with 0.001 mm accuracy. Each measurement was done 3 times to produce an average measurement for each site. The resultant casts with implant replicas (Fig 2c) were then measured using the same interimplant measurement protocol (3 times between the replica pairs to produce 3 site mean measurements for each cast). To ensure that cast vertical orientation was the same as model orientation, three scored, vertical lines, 1 on each side of model, provided reorientation lines on the resultant casts. Similarly, model and cast interimplant/interabutment score lines facilitated repeatable orientation for the microscope measurements.

For the direct/abutment-level impressions rather than interimplant measurements, interabutment measurements on the model and subsequent casts (Fig 2f) were done using the same measurement protocol.

Cast accuracy was calculated based on the percent difference between cast and model interimplant or interabutment measurements. Percent differences were reported to normalize the results, irrespective of actual interimplant or interabutment distances. Based on pilot data and a power analysis, it was determined that 5 casts per experimental group would meet the constraints of $\alpha = .05$ and power = 0.80. The data were analyzed with a 2-factor repeated-measures analysis of variance (ANOVA) to evaluate the effects related to impression technique (indirect/implant or direct/abutment level impression) and impression material viscosity combinations on the impression/cast accuracy. All statistical testing was done at the 95% level of confidence.

Table 1 Percent Difference Between the Master Model and Casts as a Function of Impression Technique

	Measurement site					
	1–2		2–3		3–1	
Impression technique*	Mean	SD	Mean	SD	Mean	SD
Closed tray/indirect/impression-level	0.02	0.11	−0.06	0.12	−0.02	0.13
Closed tray/direct/abutment-level	0.19	0.12	0.23	0.13	0.24	0.13

*Significant difference ($P < .05$) in cast accuracy between impression techniques.

RESULTS

The statistical analysis indicated there was no significant difference in cast accuracy as a function of impression viscosity; however, cast accuracy was significantly different between casts made with indirect/implant-level versus direct/abutment-level impressions. With the snap-style abutment impressions, the cast interabutment distances were larger than the master model, with the mean percent differences ranging from 19% to 24% across the 3 measurement sites. In contrast, impressions made using the metal impression coping at the implant level were not significantly different than the master model. The results of impression technique cast accuracy across impression material viscosity combinations are presented in Table 1.

DISCUSSION

Previous implant studies have evaluated implant cast accuracy in relation to different types of impression materials. When comparing materials such as polyether and vinyl polysiloxane, previous investigators reported no significant difference in cast accuracy between the materials.[8–10,12,19] Typically, the previous studies used medium- or low-body impression material syringed around the impression copings for both open and closed tray impressions. However, the current study evaluated whether heavy-body impression material might be more resistant to deformation with impressions made with either metal impression copings or plastic impression caps used with the closed tray/indirect or closed tray/direct techniques. This rationale/speculation that heavy-body material might be more resistant to deformation is the basis for a recently marketed very stiff impression material specifically for implant impressions.[15]

In the current investigation, due to the potential problems associated with impression removal with stiff impression materials,[16,17] heavy- or medium-body polyether material was syringed around impression copings or caps, with medium-body material used in the tray. Based on the study results, there was no significant difference between cast accuracy as a function of the impression material viscosity used around the impression copings/caps. This would suggest that stiffer material does not improve cast accuracy, and there probably is no need to use an impression material specific for implants.

Another very important aspect this investigation was comparing closed tray/direct and closed tray/indirect impression techniques, specifically evaluating a plastic snap-style impression cap. To date, there have been several investigations incorporating the closed tray direct and indirect techniques.[11–13,20] However, only one of those studies evaluated cast accuracy using multiple implants and a plastic impression cap. In that investigation, comparisons were made between implant-level casts made with polyether impressions using an open tray/direct technique with screw-on impression caps and a closed tray/direct technique with snap-on plastic impression caps and positioning cylinders (synOcta ITI; Straumann, Basel, Switzerland).[11] Although there were statistically significant differences when comparing the open tray/direct and closed tray/direct impression technique cast measurements, the authors concluded that there was no difference between the 2 techniques. However, the statistical comparisons appear to only be done between the casts generated by the 2 techniques rather than between the casts and the master model. When comparing the mean cast inter-implant measurements to the master model measures, it would appear that all closed tray/direct cast interimplant distances were larger than the same measurement on the master model, which is similar to what was demonstrated in the current investigation.

The evidence from the current study indicates that casts made with the closed tray/indirect technique with metal impression copings at the implant level were more accurate than casts made with the closed tray/direct technique using plastic impression caps at the abutment level, irrespective of the impression material viscosity combination. With the snap-on plastic impression caps, the cast interabutment distances were larger than the master model. The maximum cast interabutment mean ± SD percent difference from the master model was 0.24% ± 0.13%. Based on the master model interabutment distance, this translates into a range of 0.011 to 0.037 mm or a maximum of 37 µm. In contrast, with the implant-level impressions, the cast interimplant distances were almost equal to or slightly smaller than the master model, with the largest mean percent difference ± SD at 0.06 ± 0.12%, translating to a maximum discrepancy of 18 µm. Considering that osseointegrated implant movement is minimal, approximately 10 µm,[21] interabutment or interimplant cast discrepancies much larger than 10 µm would probably translate into multiple-implant restoration misfits. Moreover, it would be expected that the misfit problem would potentially be exacerbated with increasing implants and increasing distance between implants. However, this error might be more significant with screw-retained restorations as compared to cementable restorations.

With both the direct and indirect technique in the current study, the set impression was manipulated when placing either the metal coping/implant replica or abutment replica into the set impression. Accordingly, the difference in cast accuracy does not appear to be the result of impression material distortion. Instead, the decreased cast accuracy with the closed tray/direct technique could possibly be related to the impression cap being made of plastic, a viscoelastic material potentially prone to permanent distortion or deformation with loading.[22] Viscoelastic solids behave as both an elastic solid and a viscous liquid, with the ratio of elastic and viscous behavior dependent on both the material itself and the loading rate.[23] As for the potential viscoelastic-related distortion of the plastic impression caps, the distortion/deformation could occur during impression removal or even be associated with additive distortion, if the impression cap is inserted and removed multiple times prior to final impression making. A similar situation could perhaps also help explain the cast accuracy differences in the Akça and Çehreli investigation,[11] which also included plastic impression caps.

While the closed tray/direct technique using impression caps that are picked up in the impression is a good idea, if the plastic caps are susceptible to distortion, a possible alternative approach for this technique would be a snap-on metal impression cap that would not exhibit the same viscoelastic tendencies. This change in implant components could potentially make this technique as accurate as the screw-on metal impression coping, which must be removed and placed into the set impression.

CONCLUSIONS

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

1. Cast accuracy was not affected by impression material viscosity. Using a stiffer impression material around the impression coping or cap did not produce more accurate casts with either the closed tray indirect or direct technique.
2. Cast accuracy was affected by the impression technique. The closed tray/indirect impression technique using screw-on metal impression copings at the implant level yielded more accurate casts than the closed tray/direct impression technique with plastic impression caps used at the abutment level.

The clinical implication is that there potentially would be more restoration fit complications with the evaluated direct, plastic-cap impression technique when used to fabricate multiple-implant restorations.

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