Original Article

A comparative analysis of the accuracy of implant master casts fabricated from two different transfer impression techniques

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Abstract

Aim: This study evaluated and compared two impression techniques in terms of their dimensional accuracies to reproduce implant positions on working casts. **Materials and Methods:** A master model was designed to simulate a clinical situation. Impressions were made using four techniques: (1) Stock open tray (SOT) technique; (2) stock closed tray (SCT) technique; (3) custom open tray (COT) technique; and (3) custom closed tray (CCT) technique. Reference points on the hexagonal silhouette of the implant on master model and onto the analogs of the obtained master casts were compared after using the four impression techniques. Measurements were made using an optical microscope, capable of recording under 50x magnifications. The means and standard deviations of all the groups and subgroups were calculated and statically analyzed using analysis of variance (ANOVA) and Tukey's test. **Results:** The open tray impressions showed significantly less variation from the master model and all the techniques studied were comparable. **Conclusion:** All the techniques studied shown some distortion. COT showed the most accurate results of all the techniques.

Key words: *Closed tray impressions, custom trays, implants, open tray impression, stock tray, stock tray impressions*

INTRODUCTION

Titanium endosseous implants have been used for more than four decades in various edentulous situations. The emergence and acceptance of implant dentistry have given clinicians a wide variety of new alternatives for fixed and removable rehabilitations. The overall success is the ultimate replacement of the missing tooth, and this can be achieved through established prosthodontic principles. Proper impression techniques for implant dentistry should not be different from those used in conventional dentistry; therefore, proper impression techniques remain one of the foundations for prosthetic reconstruction. Failure in recording correct impression results in imprecise fit between the fixture and prosthesis, resulting in the generation of considerable stresses and it may lead to mechanical failure of an implant.

According to Balouch *et al*.,[1] there are several methods to achieve passive fitness although no distinct protocol has been introduced in this field yet. It is now believed

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that the impression materials are significantly improved; so choosing the proper technique is of prime concern. According to a review of various studies by Prithviraj *et al*.[2] where there are three or fewer implants, there is no difference between the pick-up and transfer techniques. This study was conducted to find the most accurate impression technique, along with understanding the influence of tray type for transfer of intraoral position of implant fixtures on cast.

MATERIALS AND METHODS

Model preparation

A fully edentulous maxillary resin model was made with four implants placed in the anterior region. A wax model was prepared using edentulous maxillary Frasaco mold and then it was invested, dewaxed, and acrylized by using heat cure clear acrylic resin. A stent prepared from clear acrylic resin was used to guide for the placement of implants in the master model [Figure 1]. Four implants (External Hex Implant 4.0 mm × 10 mm, Threadform; BioHorizons Implant Systems, Inc. Birmingham, West Midlands, England), two in the region of the lateral incisor and in the premolar region, respectively, were placed since this is the minimum number of implants suggested to support fixed-removable, removable prosthesis for better result. The distances between four implants of master models were measured using an optical microscope by taking sharp points of the projected hexagonal silhouettes as reference points. These distances were recorded as: A to B—7.36 mm, B to C—13.95 mm, C to D—8.15 mm, and A to D—30.65 mm. They were taken as a standard for further comparisons [Figure 2].

Fabrication of trays

Stock metal and custom acrylic were used for the impressions. Custom impression trays were fabricated using autopolymerizing acrylic resin material with 3-mm spacer and four tissue stops, two each in the anterior and posterior regions. Twenty similar special trays were fabricated by duplication. Later, perforations of 2 mm were made before making an impression for mechanical retention.

Perforations with a diameter of 1 cm opposing the guiding pins were made on the stock and custom trays for the open tray impression technique such that transfer impression coping projected from those openings. Figure 3 for closed tray impression technique, stock trays with rim lock border were used.

Figure 1: Master model

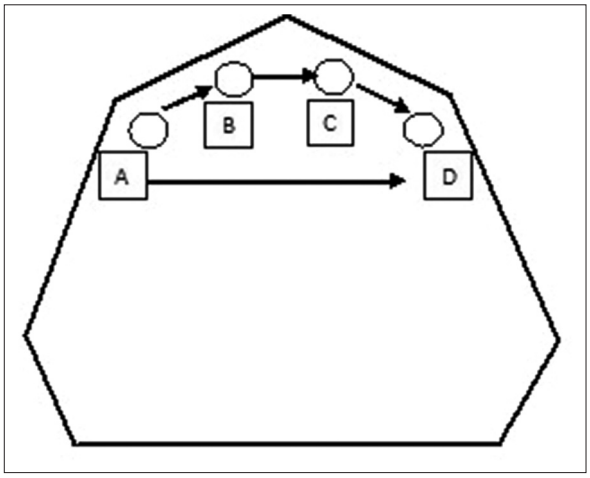


Figure 2: Schematic representation of master model

Figure 3: Tray selected for the study

Impression making

Forty polyether impressions (Impregum Penta; 3M Espe Dental AG, Seefeld, Germany) were made using

Pentamix II (3M Espe Dental AG). Four impression groups were formed as follows;

- Group 1: Stock open tray (SOT) technique
- Group 2: Stock closed tray (SCT) technique
- Group 3: Custom open tray (COT) technique
- Group 4: Custom closed tray (CCT) technique.

Ten impressions were made for each group. Before making impressions for open and closed trays, impression post and abutment with ball top screw were attached to implants [Figure 4]. The material was allowed to polymerize for twice the manufacturers' recommended setting times to allow for optimum polymerization at room temperature rather than mouth temperature.

Attachment of implant analogs

After retrieving the impression from the master model, implant analogs were attached to both open and closed tray impressions. In open tray impression technique once the impression was set, the guiding screws were removed and the impression posts were retrieved with the impression. Analogs were attached to the impression posts using the screws and the impression were poured with type IV dental stone.

In closed tray impression group, the impression was retrieved from the master model and the abutments were left with ball top screws. These were then disengaged from the model and attached to the laboratory analogs. The abutment with ball top screws and analogs assemblies were placed into their respective sites in the impressions and the casts were poured.

Preparation of casts

All the impressions were stored for 24 h before pouring. Later, Type IV gypsum (Kalrock, super hard die stone, Class IV, Kalabhai Karson Ltd., Mumbai, Maharashtra, India) was mixed according the manufacturers' directions (23 cc water and 100 gm powder). The casts were separated from the impression after 1 h [Figure 5].

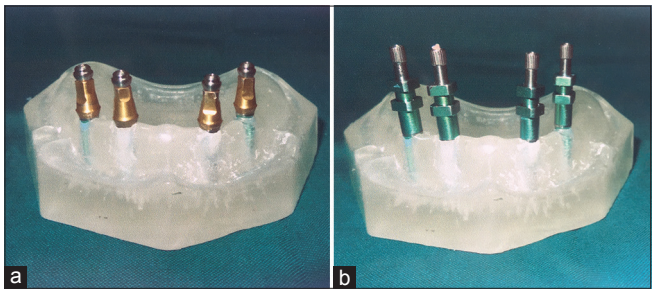


Figure 4: (a) Master model having abutment with ball top screw (b) Master model with impression post

Measurement of casts

All the casts were stored at room temperature for a minimum of 24 h before the measurements were made. A calibrated optical microscope (Depew, NY, USA) was used to record the positional accuracy of the implants. All the measurements were made under 50x magnifications. The optical microscope allowed measurement of linear distances with an accuracy of 0.01 mm (1 μm).

The interimplant distance was measured using the optical microscope between the three reference margins of the implant, i.e., from A to B, B to C, and C to D. The longer distance from A to D was measured using electronic digital micrometer having a measurement capacity of 1 mm since the optical microscope cannot measure distances over 16 mm.

The mean and standard deviation were calculated for models and casts for each dimension for all the groups. All *P* values were obtained using one-way analysis of variance (ANOVA) test and intragroup comparison was done using Tukey's test.

RESULTS

Comparison of distance between A and B

By using ANOVA test $P < 0.05$, there is a significant difference between SOT, SCT, COT, and CCT with respect to mean distance. Minimum distance was found in the SCT group with a mean of 7.26 mm (±0.09) and maximum distance was found in the CCT group with a mean of 7.55 mm (±0.08).

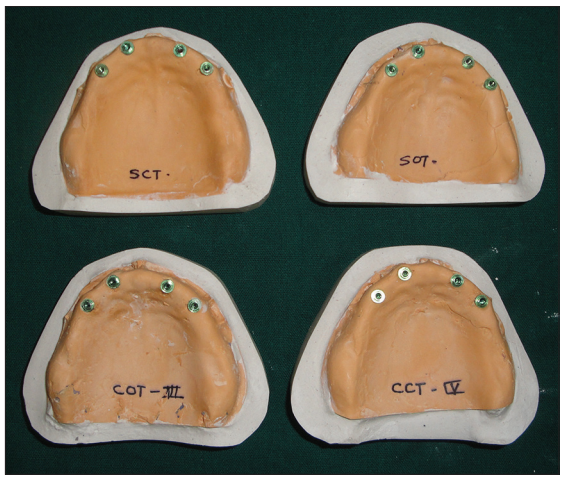


Figure 5: Casts poured using stock closed tray SCT, stock open tray SOT, custom closed tray CCT, custom open tray COT

Comparison of distance between B and C

By using ANOVA test, *P* value was <0.05; therefore, there is a significant difference between SOT, SCT, COT, and CCT with respect to mean distance. Minimum distance was found in the SCT group with a mean of 13.82 mm (±0.10) and maximum distance was found in the CCT group with a mean of 14.10 mm (±0.09).

Comparison of distance between C and D

By using ANOVA test, *P* value was <0.05; therefore, there is a significant difference between SOT, SCT, COT, and CCT with respect to mean distance. Minimum distance was found in the SOT group with a mean of 8.08 mm (±0.05) and maximum distance was found in the CCT group with a mean of 8.22 mm (±0.16).

Comparison of distance between D and A

By using ANOVA test, *P* value was <0.05; therefore, there is a significant difference between SOT, SCT, COT, and CCT with respect to mean distance. Minimum distance was found in the COT group with a mean of 30.70 mm (±0.04) and maximum distance was found in the CCT group with a mean of 30.80 mm (±0.04).

DISCUSSION

Perfect passive fit in the interface between abutment and implant is difficult to obtain because of the different factors that affect the process of fabricating prostheses such as different system tolerance, type of abutment used, properties of metallic alloy and impression materials, investing, and casting problems. Moreover, abutment position distortion has often accompanied transfer impression techniques. The ability of the clinician to perform impression-related procedures is fundamental for the quality of the prosthesis.[3]

The common impression techniques using open and closed tray with stock metal and special acrylic trays were assessed.[4] Alan B Carr *et al*. and Daoudi *et al*. found that the direct transfer method was more accurate than the indirect transfer method.[4,5] But Humphries *et al*. and Herbst *et al*. found that dimensional accuracy was exceptional for all the studies.[6,7]

Direct transfer method can either be done with or without splinting. Dual cure resin and plaster have been used for splinting purpose. According to Assif *et al*., plaster was used for splinting the impression posts. Kim *et al*. found that the nonsplint technique was more accurate during the impression-making procedure while the splint technique was more accurate during the cast fabrication procedure.[8,9] MR Baig found that the evidence on splinting was inconclusive and the data supporting splint to nonsplint were neutral.[10] Conflicting reports were found on splinting for impression accuracy.[11-14]

A single impression material polyether was chosen as it showed many superior qualities than other elastomeric impression materials. Liou *et al*. and Wee found no significant difference in the accuracy of impression materials using polyether and VPS impression materials and this is also supported by many other authors.[14-19] Regarding the manipulation of the impression material, mechanical mixing of impression material was chosen since hand mixing results in air entrapment during spatulation. This leads to the formation of both surface and subsurface bubbles, which in turn may result in inaccurate dental impressions and/or jeopardize their physical properties.[20]

Comparison with the mean and standard deviation of all the groups and intragroup comparison were calculated. They were statistically analyzed using one-way ANOVA and Tukey's test as seen in Table 1.

For distance A to B, when the readings were evaluated [Table 1 and Graph 1] it was observed

Table 1: Comparison of distances between A and B, B and C, C and D, and A and D with respect to methods SOT, SCT, COT, and CCT

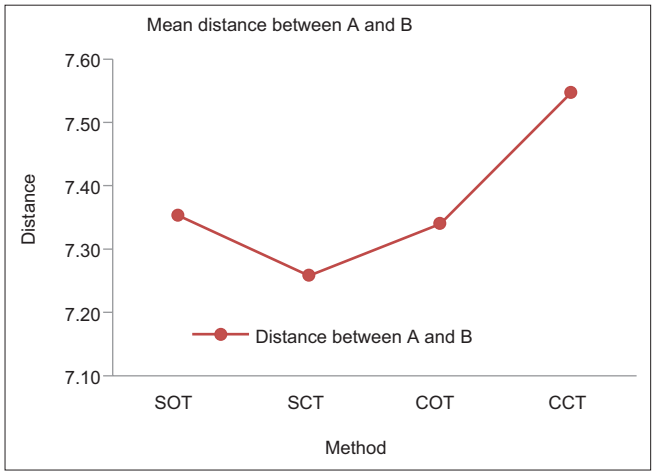
Group	Number of samples	Distance between A and B (mean±SD)	Distance between B and C (mean±SD)	Distance between C and D(mean±SD)	Distance between A and D (mean±SD)
SOT	10	7.35±0.08	13.85±0.03	8.08±0.05	30.72±0.05
SCT	10	7.26±0.09	13.82±0.10	8.16±0.11	30.79±0.10
COT	10	7.34±0.06	13.91±0.03	8.16±0.07	30.70±0.04
CCT	10	7.55±0.08	14.10±0.09	8.22±0.16	30.80±0.04
F value		25.08	30.96	3.075	6.24
P value		<0.001	<0.001	0.040	0.002

SOT=Stock open tray SOT technique, SCT=Stock closed tray technique, COT=Custom open tray technique, CCT=Custom closed tray technique

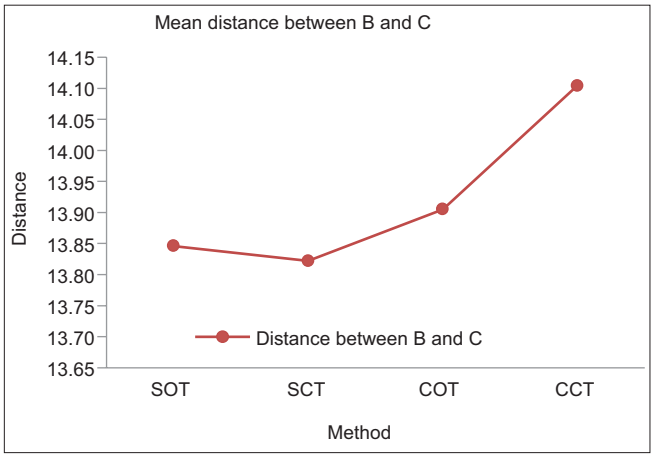
that the readings of SOT method (7.35 mm) and COT (7.34 mm) method were more close to the reading of Master model (7.36 mm). Similarly for distances between B to C, C to D and A to D [Table 1 and Graphs 2– 4] readings of SOT method and COT method are more close to that of master die as compared with SCT and CCT. This indicates that both the stock and CCTs are less accurate as compared to open tray impression techniques. This accords to the evidence of the study by Baig and Karl.[10,21] It is supported by various studies.[5,10,15,22-25]

The reason for this is that the open tray impression allows the copings to be removed, along with the impression by unscrewing and the implant analogs are directly connected to these copings to fabricate the definitive cast. There is avoidance of movement of the impression copings inside the impression material throughout the procedure. Also, unscrewing the guide pins from the impression copings when the tray is removed or screwing the matching implant replicas in the impression do not cause any movement and results in an accurate cast.

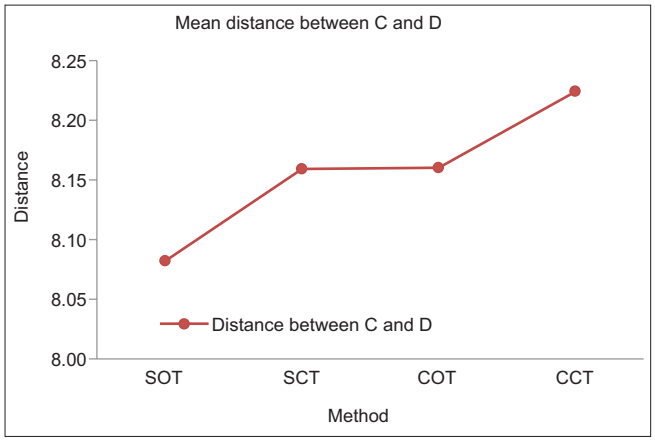
When the intergroup results were compared [Table 1], it was found that the closed impression using both stock metal and custom acrylic was more inaccurate. The inaccuracy in the closed tray impression technique is similar to the findings of Jorgenson in that a permanent deformation was induced in the impression material when recovering it from structures having undercuts 1.0 mm in height and depth. The transfer coping below the height of contour could easily provide such an undercut and lead to deformation.[4,26] This can be attributed to the linear setting expansion of the die stone[25] and after making impressions, the implant analogs could not be placed correctly at the same position. Spector *et al*. attributed the inaccuracies in repositioning the implant analogs to the dimensional instability of materials as well as the mechanical errors in positioning the components during the impression procedure.[11]



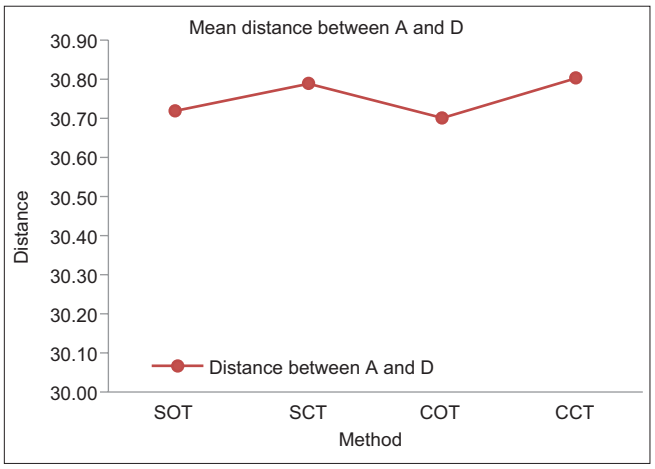
Graph 1: Comparison of four impression groups with respect to distances (in mm) between A and B with the master model



Graph 2: Comparison of four impression groups with respect to distances (in mm) between B and C with the master model



Graph 3: Comparison of four impression groups with respect to distances (in mm) between C and D with the master model



Graph 4: Comparison of four impression groups with respect to distances (in mm) between A and D with the master model

Subgroup comparison was done [Table 1] between SOT group and COT method. A significant difference was seen between the two (<0.001). COT readings were closer to master die readings as compared to SOT. The reason was that in the custom tray, there is a uniform thickness and an even bulk of the impression material, which leads to even contraction of the elastomeric impression material away from the specimen as it is adhered to the tray by the adhesive and not to the specimen. It was possible to make accurate stock tray impressions although the accuracy was not as consistent compared to custom tray.[27] These findings are supported by Bomberg *et al*. and Treml *et al*.[3,28-30]

However, this study does not shows the accuracy in impressions carried out on implants placed at various angulations. Also, it does not evaluate the accuracy with impressions carried out with implants splinted with different splinting materials such as dental floss and pattern resin.

CONCLUSIONS

Within the limitations of the present study, the following conclusions can be drawn:

- The open tray impression technique is more accurate as compared to the closed tray technique
- There is a significant effect of change in the type of trays on the accuracy of impressions
- COT shows the most accurate impression technique among all.

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Conflicts of interest

There are no conflicts of interest.

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