To Compare the Dimensional Accuracy of Casts Obtained from Different Impression Techniques in Implant Prosthodontics: An In-Vitro Study

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Introduction

Obtaining an appropriate impression of the implant position and surrounding soft and hard tissues is paramount to fabricating an esthetically and biologically functional definitive restoration.

Materials and Methods

An edentulous maxillary acrylic master model was chosen. Four dummy implants were drilled into this model from the first premolar to first premolar region at equal distance using a dental surveyor to ensure parallel placement of the implants. Ten samples, each made for open tray (Group A), closed tray direct (Group B), and closed tray indirect (Group C) techniques using polyvinylsiloxane, were poured in type IV dental stone and 30 samples were hence obtained. The linear distance between the four implants were measured using the profile projector for each of the cast. The data obtained were analyzed using ANOVA and Tukey’s HSD test.

Observation and Results

Inter-implant and inter-abutment linear distances were measured (in mm) for the master model and the samples for 1 to 2, 2 to 3, 3 to 4, 1 to 3, 2 to 4, and 1 to 4, and the maximum deviation was found in Group B.

Conclusion

The dimensional accuracy of casts obtained from closed tray indirect impression technique was the highest with linear distance values closest to the implant master model followed by open tray, and the least accuracy was found for closed tray direct impression technique.
impression technique, certain considerations such as limited approach to implants in the posterior region, restricted inter arch space, and tendency to gag dictate the use of the closed tray technique.¹ The open tray direct technique requires a custom tray or a modified stock tray with screw access holes in the areas occlusal to the implants. The technique involves fastening an impression post to the implant with a screw that protrudes above the height of the post and through an opening in the custom impression tray that is used. This technique reduces the impact of implant angulations and also decreases deformation of impression material upon recovery from mouth.²

The closed tray indirect technique uses an impression post that remains attached intraorally to the implant. Once the impression is pulled out from the mouth, the post is unscrewed from the implant, attached to the implant analog, and correctly positioned back in the impression.³

The closed tray direct technique uses abutments attached intraorally to the implant. The impression is made with snappy plastic impression caps on the abutments. Impression caps are retained in the impression. The abutments are then unscrewed and positioned in the impression caps.

There may be clinical situations that indicate the use of closed tray techniques. The closed tray indirect tray impression techniques are being used with increased frequency, impression approach is simpler, there is also a potential for impression inaccuracy, so the reliability of these impression techniques is a matter of concern. Obtaining an appropriate impression of the implant position and surrounding soft and hard tissues is paramount to fabricating a restoration.⁴

Therefore, keeping in mind the importance of an accurate cast, a comparative analysis of implant cast accuracy as a function of three different impression techniques has been done in this in vitro study.

Aims and Objectives

The study was conducted to compare and evaluate the dimensional accuracy of casts obtained from different impression techniques obtained from open tray, closed tray direct, and closed tray indirect impression techniques.

Materials and Methods

Materials and armamentariums used in this study were tray adhesive (VPS tray adhesive; 3M ESPE; Delhi), heat cure acrylic polymer and monomer (DPI; Dental Products Pvt. Limited; Mumbai), polyvinylsiloxane impression material—putty consistency (3M ESPE), polyvinylsiloxane impression material—light body (3M ESPE), an edentulous maxillary master model, stock dentulous trays (API; FMCG manufacturer; Mumbai), dummy Implants (Nobel Biocare 4.3 × 13 mm; regular platform), implant analogs (Nobel Biocare 1.5 × 4.3 mm), impression posts (Nobel Biocare), snappy plastic impression caps (Nobel Biocare), implant screw driver (Nobel Biocare), polythene Vacuform sheet (4 mm thick; Bioplast), profile projector (Dyna scan, India) and vacuum forming machine (Vacuform, India).

Methods

Implant Master Model

An edentulous maxillary acrylic master model was made. For the construction of the same, a standard maxillary mold was used, it was filled with melted impression compound material and a maxillary impression compound cast was obtained.

Flasking and dewaxing were done and the acrylic master model was hence obtained. Four implants analogs were drilled into this model from the first premolar to first premolar region at an equal distance using a dental surveyor to ensure parallel placement of the implants. The analogs were numbered 1, 2, 3, and 4 (→ Fig. 1).

Fabrication of Custom Tray for Open Tray Impression Technique

A 4 mm thick polyethylene vacuform sheet was adapted over the implant master model with impression posts screwed in the implant analogs drilled in the master model with the help of the vacuum-forming machine to provide uniform space for the impression material during impression making. An alginate impression of the master model with the sheet adapted was made and poured in the dental stone to obtain the cast. Two sheets of modeling wax were adapted over the cast and wax up completed for the tray. During the wax up, a section of the wax was removed from over the impression posts. After the wax up was completed flasking, dewatering was done and custom tray fabricated in heat cure acrylic resin. The tray was finished and polished (→ Fig. 2).

Fabrication of the Custom Tray for Closed Tray (Direct) Impression Technique

For closed tray direct impression technique, a 4 mm thick Bioplast polyethylene vacuform sheet was adapted over the implant master model with abutments, while snappy plastic impression caps were screwed in the respective implant analogs drilled in the implant master model. An alginate impression of the implant master model with the sheet...
adapted was made and poured in dental stone to obtain the cast. Two sheets of modeling wax were adapted over the cast and wax up completed for the tray. After the wax up was completed, flasking and dewaxing were done and custom tray fabricated in heat cure acrylic resin. The tray was finished and polished. The tray handles were made of autopolymerizing acrylic resin. The tray was perforated creating equally spaced holes using a no. 8 round bur. The tray thus obtained was used for closed tray direct impression technique (►Fig. 3).

**Fabrication of the Custom Tray for Closed Tray (Indirect) Impression Technique**

The closed tray impression posts were screwed in the implant analogs drilled in the master model with a 4 mm thick bioplastic polyethylene vacuform sheet adapted over the implant master model using the vacuum-forming machine to provide uniform space for impression material during impression making. An alginate impression of the master model with the sheet adapted was made and poured in the dental stone to obtain the cast. Two sheets of modeling wax were adapted over the cast and wax up was completed for the tray. After the wax up was completed, flasking and dewaxing were done and custom tray fabricated in heat cure acrylic resin. The tray was finished and polished. The tray handles were made of autopolymerizing acrylic resin. The tray was perforated creating equally spaced holes using a no. 8 round bur. The tray thus obtained was used for closed tray indirect impression technique (►Fig. 4).

**Impression Technique**

Impression posts were connected to each of the implant analog in the implant master model. The tray was coated with a thin layer of tray adhesive and allowed to dry for 10 minutes. Impression was made using putty and light body polyvinylsiloxane impression material using single-step putty wash technique. The impression posts were exposed through the open tray access after removing the impression material that covered the copings (for Group A) and unscrewed from the model in case of (Groups B and C). The impression material was allowed to set as per manufacturer’s recommendation. The impression posts were then unscrewed through the custom tray access opening using a screwdriver. The set impression was then removed from the master model. The impression posts were retained in the impression. The implant analogs were screwed with the impression posts. The impression was poured using a type IV dental stone to obtain casts with the implant analogs in it. A maxillary base former was used to fabricate the base of the casts. The casts so obtained after removal of the impression posts were subjected to linear inter-implant distance and inter- abutment distance analysis on a Profile Projector possessing an accuracy of 0.001 mm.

For the implant master model and the study models obtained, the reference point to measure linear inter-implant distance between the implant analogs was taken as the midpoint of the diameter of the analog. In total, 30 casts were poured with 120 analogs and linear inter-implant distance
Fig. 3  Closed tray (direct) impression technique.

Fig. 4  Closed tray (indirect) impression technique.
between point 1–2, 2–3, 3–4, 1–4, 1–3, and 2–4 were measured. The 180 readings thus recorded were tabulated as per the groups, statistically analyzed using ANOVA and Tukey's HSD.

**Observation and Results**

The linear distance was measured from the midpoint of each of the scanned analog progressing from the reference points 1 to 2, 2 to 3, 3 to 4, 1 to 4, 1 to 3, and 2 to 4. The scanned configuration was then subjected to mathematical analysis. The linear distance was measured from the midpoint of the implant analog and the abutment for each of the cast obtained from the reference points 1 to 2, 2 to 3, 3 to 4, 1 to 4, 1 to 3, and 2 to 4. The platform table of the Profile Projector machine was used as the reference plane to inculcate uniformity in measurement of the linear distances. Measurement of multiple distances was made to ensure better accuracy and make the study more clinically significant.

All measurements were recorded three times by the same operator and the mean value was calculated. The measurements of the master model and the stone casts obtained with three impression techniques were tabulated statistically analyzed using the ANOVA test and Tukey's HSD test. Ten samples were made under each group. Impressions were made and poured using die stone (type IV). A maxillary base former was used to fabricate the bases of the casts obtained. The 30 casts obtained from impressions were then subjected to linear inter-implant and inter-abutment distance analysis using Profile Projector (Fig. 5). After analysis of 30 samples obtained from three impression techniques, the observations of linear distances were made using Profile Projector (Figs. 6–11).

The observations so made were subjected to statistical analysis and the means of the linear inter-implant and inter-abutment distances obtained, were compared with those of the clear acrylic master model using ANOVA test and Tukey’s HSD test (Tables 1–8).

**Discussion**

As a result of the present investigation, the closed tray indirect impression technique generated linear distance values closest to the master model, thereby being the most accurate technique. The linear distance variability of the samples made from closed tray indirect impression technique was found to be statistically significant with respect to all distances. The standard deviation for group C samples was
found to be less than Groups A and B samples for all the linear distances measured. The mean difference for group C samples was found to be the least for all the linear distances measured. Hence, the evidence of the current study indicated that casts made with closed tray indirect impression technique with metal impression posts at the implant level were most accurate than the casts made with open tray and the closed tray direct technique using snappy plastic impression caps at the abutment level. The less the mean difference, standard deviation, and statistically significant values, the more the accuracy of the technique. This technique showed a little inaccuracy as compared with the open tray technique in case of 3–4, which may be only due to manual repositioning of the coping-analog assembly in the impression.

**Fig. 7** Mean of linear distance (2–3) for group A, B, and C casts, respectively.

**Fig. 8** Mean of linear distance (3–4) for group A, B, and C casts, respectively.
The second-most accurate technique according to the present investigation was the open tray implant impression technique. The linear distance variability of the samples made from open tray impression technique was found to be statistically significant with respect to all the inter-implant distances. The mean difference for Group A samples was found to be least in 3–4 distances measured. The mean distance was found to be statistically significant for almost all the six distances measured. The standard deviation for group A samples was found to be least in 3–4 distances measured with exception of distance 1–4. Hence, the open tray impression technique was found to be more accurate than closed tray direct impression technique and less than closed tray indirect technique. The enhanced accuracy of this technique could be attributed to the retention of the impression posts in the impression, eliminating the need to manually

![Fig. 9](image)

**Fig. 9** Mean of linear distance (1–4) for group A, B, and C casts, respectively.

![Fig. 10](image)

**Fig. 10** Mean of linear distance (1–3) for group A, B, C, and casts, respectively.
reposition the posts in the impression. The presence of screw access holes in the areas occlusal to the implants held the impression posts correctly positioned against each implant. The principal advantage of this technique was that the impression posts remained in the impression and the inaccuracies of transferring were avoided. With multiple implants, this technique was found to be most accurate as first the impression was easily retrievable and second there was minimum distortion of the impression material.\textsuperscript{5,6}

In a study, Carr \textsuperscript{7} compared the open tray and closed tray techniques with a 5-implant mandibular cast where the interabutment divergence angles were all less than 15 degrees. The authors found that the open tray technique was found to be superior as it provided most accurate working cast.

The implant impression technique, third in accuracy according to the present investigation, was closed tray direct impression technique. The linear distance variability of the samples made from closed tray direct impression technique was found to be statistically significant with respect to all distances. The standard deviation for group B samples was found to be maximum for all linear distances measured with the exception of distance 1–4. The mean difference of group B

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Fig_11.png}
\caption{Mean of linear distance (2–4) for group A, B, C, and casts, respectively.}
\end{figure}

### Table 1
Linear inter implant distance value on master model

<table>
<thead>
<tr>
<th>Master model</th>
<th>Distance (1–2)</th>
<th>Distance (2–3)</th>
<th>Distance (3–4)</th>
<th>Distance (1–4)</th>
<th>Distance (1–3)</th>
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<tr>
<td>Inter-implant distance (in mm)</td>
<td>10.750</td>
<td>24.840</td>
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### Table 2
Linear inter abutment distance value on master model

<table>
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<th>Master Model</th>
<th>Distance (1–2)</th>
<th>Distance (2–3)</th>
<th>Distance (3–4)</th>
<th>Distance (1–4)</th>
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</thead>
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<tr>
<td>Inter-implant distance (in mm)</td>
<td>11.755</td>
<td>25.347</td>
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### Table 3
Comparison of Linear distance 1–2 (using ANOVA test) for group A, B, and group C casts, respectively

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<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
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<th>Maximum</th>
<th>F</th>
<th>p-Value</th>
<th>Significance</th>
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<td>Group A</td>
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<td>10.5978</td>
<td>0.11971</td>
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<td>Group B</td>
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<td>12.0582</td>
<td>0.12546</td>
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<td>Group C</td>
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<td>10.7464</td>
<td>0.20170</td>
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### Table 4
Comparison of Linear distance 2–3 (using ANOVA test) for groups A, B, and C casts, respectively

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<th>Mean</th>
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<th>Maximum</th>
<th>F</th>
<th>p-Value</th>
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<td>25.8078</td>
<td>0.11727</td>
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<td>Group B</td>
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<td>26.0461</td>
<td>0.62507</td>
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<td>27.03</td>
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<tr>
<td>Group C</td>
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<td>25.0297</td>
<td>0.41806</td>
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### Table 5
Comparison of Linear distance 3–4 (using ANOVA test) for groups A, B, and C casts, respectively

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<td>10.4801</td>
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<td>10.59</td>
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<td>Group B</td>
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<td>11.7734</td>
<td>0.51823</td>
<td>0.16388</td>
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<td>12.54</td>
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<tr>
<td>Group C</td>
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<td>10.8507</td>
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<td>10.17</td>
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</table>
samples revealed the maximum standard deviation, the highest mean difference from the master model, and that too statistically significant with respect to three out of six linear distances measured, this technique was considered the least accurate. The decrease cast accuracy could be due to the impression caps being made of plastic, a viscoelastic material potentially prone to a permanent distortion or deformation with loading.

Within the limitations of this study, it might be concluded that when four implants were used, the closed tray indirect impression technique could be recommended ensuring the accuracy in implant level impressions. Closed tray direct technique with the use of plastic transfer caps might be considered reliable but studies are required concerning the use of metal caps for better accuracy. The results obtained were in agreement with most of the previous studies.

Conflict of Interest
None declared.

References
3 Elshenawy EA, Alam-Edein AM, Abd Elfatah FA. Cast accuracy obtained from different impression techniques at different implant angulations (in vitro study). Int J Implant Dent 2018;4(01):9

Table 6 Comparison of Linear distance 1–4 (using ANOVA test) for groups A, B, and C casts, respectively

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
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<td>36.2016</td>
<td>1.01730</td>
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<td>36.1065</td>
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Table 7 Comparison of Linear distance 1–3 (using ANOVA test) for groups A, B, and C casts, respectively

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<tbody>
<tr>
<td>Group A</td>
<td>10</td>
<td>32.3475</td>
<td>0.78694</td>
<td>0.24885</td>
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Table 8 Comparison of Linear distance 2–4 (using ANOVA test) for groups A, B, and C casts, respectively

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<tbody>
<tr>
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<td>33.14</td>
<td>0.011</td>
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Conclusion
The dimensional accuracy of casts obtained from open tray direct impression technique was the highest than close tray indirect impression technique and least from closed tray direct impression technique with the linear distance values showed the maximum deviation from the implant master model but deviations were within accepted range.

When multiple implants are used the open tray direct implant impression technique could be recommended. The selection of the impression technique is based on the clinical situation and the clinician’s preference.