Original Article

Comparative evaluation of accuracy of six different implant impression techniques: An *in vitro* study

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AIM: To identify the most accurate impression technique and the ideal impression material to transfer the intra-oral position of implant fixtures to the working cast. **MATERIALS AND METHODS:** About 30 impressions of the reference model were made using polyvinyl siloxane (Group I) and polyether (Group II) with 15 impressions each. Each group was subdivided into three subgroups based on the trays used; stock metal tray, closed custom tray, and open-window custom tray. Specific dimensions of the resultant casts were measured using coordinated measuring microscope. Mean actual cast error and subgroup's actual cast error was calculated and statistically analyzed using ANOVA. **RESULTS:** The subgroup's mean actual cast error observed in Group I - A, B, and C was 0.02825 ± 0.0091, 0.01679 ± 0.0055, and 0.08442 ± 0.01516 mm, respectively. The subgroup's mean actual cast error observed in Group II - A, B, and C was 0.03035 ± 0.0164, 0.01924 ± 0.0051, and 0.0212 ± 0.010 mm, respectively. There was no statistical significance between the observed differences. **CONCLUSIONS:** All the techniques studied showed some distortion and the difference had no statistical significance. The selection of impression technique and impression material can be based on clinical situation and according to the clinician's preference.

Key words: Closed tray impressions, open tray impressions, plaster splinting for open tray impressions

Osseointegrated implants have proved to be successful beyond doubts. Even though predictable long-term results can now be achieved; certain failures do occur. Failures may be attributed to the inaccurate fit of the prosthesis, to the implant components or to faulty surgical techniques. Inaccurate fit produces abnormal stress, which can result in fracture of the prosthesis, the fixtures, the screws, or the bone.

To achieve a precise, passive fitting prosthesis different tray types, impression materials and impression techniques have been suggested in the literature. The results in previous studies are quite contradictory and confusing. This study was conducted to find the most accurate impression technique and to know the influence of the tray type and impression material in transferring the intra-oral position of implant fixtures to the working cast.

MATERIALS AND METHODS

An edentulous mandibular cast with four implant analogues (5.6 mm) in the anterior region and a metallic insert in the posterior region was used as the reference model [Figure 1]. Three types of impression trays were used; they were (i) metal stock trays, (ii) closed custom trays, and (iii) open custom trays [Figure 2]. Metal stock trays (Sun German) were selected such that at least a minimum of 3 mm space was obtained around the impression post. Custom impression trays were fabricated using autopolymerizing acrylic resin with 3 mm space for impression material. Five identical custom trays were made by duplication. Windows were created in the same trays for making the open tray impressions after the completion of closed-tray impressions. Vertical stops were incorporated using autopolymerizing acrylic resin in all trays, to facilitate repeated positioning and to prevent over-seating of the impression tray.

Six impression techniques were studied. They were:

Group I - Polyvinyl siloxane impressions (putty and light body)
(3M ESPE, express STD, firmer set)
Sub-group A - using stock metal tray
Sub-group B - using closed custom tray
Sub-group C - using open-window custom tray
Group II - Polyether impressions (medium body)
(3M ESPE Impregum soft)
Sub-group A - using stock metal tray

Figure 1: The reference model with impression posts on the implant analogues

Figure 2: Impression trays used, stock metal tray, closed custom tray, open window custom tray

Figure 3: Polyvinyl siloxane impressions made using stock tray, closed custom tray and open window custom tray (from left to right)

Figure 4: Polyether impressions made using stock tray, closed custom tray and open window custom tray (from left to right)

Figure 5: Coordinated measuring microscope (Check Master, HELWEL)

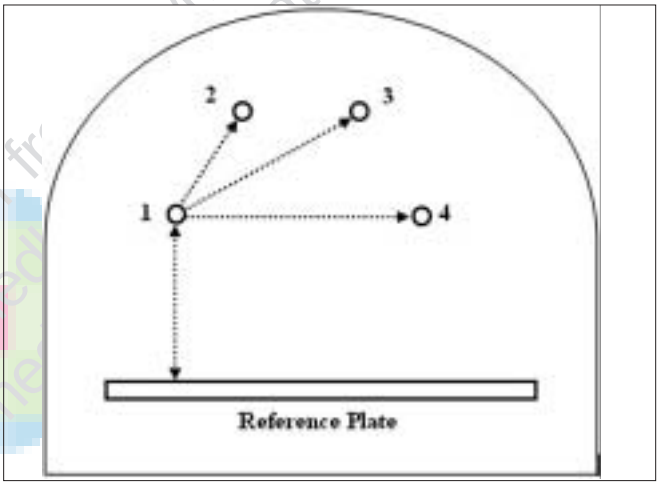

Figure 6: Schematic picture showing measurements made

Sub-group B - using closed custom tray
Sub-group C - using open-window custom tray

The impression posts were connected to implant analogues with the screws tightened manually such that their flat surfaces were facing buccally. The longer impression posts were connected to the anterior analogues and shorter were connected to the posterior analogues. Five impressions were made for each sub group.

In Group I - Polyvinyl siloxane impressions, the trays were coated with a uniform layer of tray adhesive (3M ESPE VPS tray adhesive) and were allowed to dry for 15 minutes according to manufactures instructions. Impressions were made with putty and light body using Dual mix technique. The impressions were allowed to set for 10 minutes (twice the manufacturer's recommendation time) under a standard load of 500 gm. The load was applied uniformly on the tray using a

tripod stand.

In sub-group A, stock metal trays were used and in sub-group B closed custom-made trays were used. In sub-group C, open window custom trays were used. During impression making the excess material was removed through the open window to expose upper portion of the impression post. After the final set of the impression material, fast setting plaster was injected for splinting the impression posts [Figure 3]. In group II, impressions were made using medium consistency poly ether material [Figure 4], while the impression procedure and the trays used in the sub-groups were similar to sub-groups of group I.

The closed tray impressions were separated from the master model leaving behind the impression posts. Then the impression posts were disconnected from master model and connected with laboratory analogues. The impression post and analogue assemblies were positioned into their respective sites in the impression and casts were poured. Whereas in open tray impression group after impression material was set the screws were unscrewed and the impression posts were picked along with the impression. Analogues were connected to the impression posts using the screws and casts were poured.

All the impressions were poured using the same quantity of Type IV dental stone. According to the manufacturer's instruction 100 grams of powder was mixed with 22 mL of distilled water using a vacuum mixer (Wehmer) to pour the casts. The casts were allowed to set for 1 hour before removal from the impression. Only one cast was formed from one impression. The casts were subjected to measurement after 24 hours to simulate clinical situation.

Measurements were made using co-ordinated measuring microscope (Check Master, HELWEL, Niagarafalls, NY) capable of measuring in X-, Y-, and Z- axes with an accuracy of ±5 µm [Figure 5]. The microscope was connected to a data processor (Geomet 301). A self-calibration test was performed to determine the accuracy obtained by the single evaluator. The mean intraoperator error was ±2 µm in X-, Y-axis, and ±1 µm in Z-axis. The measurements of the master model were made to provide the reference. To make the measurements, the impression posts were connected and their circular portion was chosen to make readings. By loading four points around the circumference, the data processor could compute the midpoint of the posts in two dimensions.

The vertical plate of metallic insert was taken as the reference plane. The implant analogue 1 was located in reference to this vertical plate and the distance between them was measured. After the implant analogue 1 was located in X-, Y-axis, it was used as the reference to locate the position of remaining three analogues. The center points of the implants analogues 2, 3, and 4 were located. The shortest distance between analogues 1 and 2, 1 and 3, and 1 and 4 were given by the data processor. The measurements of all experimental casts were obtained using the above-mentioned procedure as shown in the schematic picture [Figure 6].

The values of experimental cast were then subtracted from the corresponding linear distance of the master model, to get the deviation in millimeters. Irrespective of positive or negative values only actual values were taken for statistical analysis.

The four linear measurements of each cast were averaged to get the mean actual cast error. Then the mean actual cast errors of five models in a subgroup were averaged to get the sub-group's mean actual cast error with standard deviation.

The mean and standard deviation estimated from the samples for each subgroup were statistically analyzed. Mean values were compared by one-way analysis of variance (ANOVA). Multiple range test by Tukeys-HSD procedure was employed to identify the significant groups at 5% level. In the present study, $P \leq 0.05$ was considered as the level of significance.

RESULTS

Mean actual cast error and subgroups mean actual cast error for Group I and II were calculated and are tabulated in Tables 1 and 2. They were statistically analyzed using one-way ANOVA and the result obtained is shown in Table 3. It was found that when stock metal tray and closed custom tray were used PVS impressions were superior and when open-window custom tray was used polyether impressions were superior. However the difference noticed between the impression materials was not statistically significant.

DISCUSSION

An accurate impression is the most important step to achieve properly fitting implant supported prosthesis. This study was designed to identify the most accurate impression technique; the ideal tray type and the impression material for implant impressions. A reference model with four implant analogues was used in our research since the minimum number of implant suggested to support a fixed implant supported complete denture prosthesis is four.[1,2]

The impression techniques that are commonly followed were evaluated, namely stock metal tray, closed custom tray and open-window custom tray impression techniques. Their indications, merits and demerits are described in the literature.[3] Carr, Daovdi *et al*. from their research showed that direct transfer method (Open tray) is more accurate than the indirect transfer method (Closed tray)[3,4] Whereas Humphries *et al.* and Herbst *et al*. from their studies concluded that the dimensional

Table 1: Mean actual cast error of Group I - Polyvinyl siloxane impressions

Sub-group	Mean actual cast error (mm)					Mean subgroup error
	Model 1	Model 2	Model 3	Model 4	Model 5	
A	0.0150	0.0405	0.02975	0.02975	0.02625	0.02825 ± 0.0091
B	0.0100	0.0157	0.01975	0.014	0.0245	0.01679 ± 0.0055
C	0.0077	0.0252	0.355	0.0307	0.0035	0.08442 ± 0.1516

Table 2: Mean actual cast error of Group II - Polyether impressions

Sub-group	Mean actual cast error (mm)					Mean subgroup error
	Model 1	Model 2	Model 3	Model 4	Model 5	
A	0.042	0.052	0.028	0.015	0.01475	0.03035 ± 0.0164
B	0.0245	0.0212	0.02225	0.0165	0.01175	0.01924 ± 0.0051
C	0.027	0.033	0.013	0.025	0.008	0.0212 ± 0.010

Table 3: Comparison of mean and standard deviation of the errors obtained from the different tray types while using polyvinyl siloxane and poly ether (mm) - Group I and II

Subgroups	Group I - PVS	Group II - Poly ether	*P*- value and Significance at 5% level
Stock metal tray	0.02825 ± 0.0091	0.03035 ± 0.0164	0.544832
Closed custom tray	0.01679 ± 0.0055	0.01924 ± 0.0051	Not significant
Open custom tray	0.08442 ± 0.1516	0.0212 ± 0.010	

accuracy was exceptional for all techniques.[5,6]

Open tray impressions can either be made with or without splinting. Materials like autopolymerizing resin, dual cure resin, and plaster have been suggested for splinting the impression posts. Based on the results of Assiff D, plaster was selected for splinting the impression posts.[7] Even though many impression materials were tried in making implant impressions, Wee AG concluded from his study that either polyether or addition silicone must be used for making direct implant impressions.[8]

The casts obtained were measured for specific dimensions and were compared with the master model to know the amount of distortion. The distortion can be defined and measured as 'absolute' or 'relative'.[8] In absolute distortion analysis,[9] an external reference point is used and in relative distortion analysis,[3,5,10] one of the abutment replica / impression coping is used as the reference. The amount of strain in the implant prosthetic-implant bone system is related to the relative position of the implant abutments to one another and not to an external reference point. So for clinical relevance relative distortion analysis is suggested than absolute distortion analysis.[8]

The accuracy of impression can be assessed either by measuring the impression itself[9] or by measuring the resultant cast.[3,5,8,10-12] When the casts are measured, the end result is assessed, it simulates clinical situation and eliminates the need for follow up studies. In the present study relative distortion analysis was performed to make it clinically relevant and to eliminate the need for follow up studies.

The results as seen in Table 3 show that in the impression stage some distortion would occur. This can be attributed to the flexibility of impression tray, difference in the thickness of impression material,[13] setting shrinkage of the material, setting expansion of the material used for making cast and the water powder ratio used. All these factors put together could have resulted in the distortion of the resultant cast.

The mean error values of the custom tray impressions were found to be more accurate than stock metal tray impressions. This can be explained by the difference in the thickness of impression material and setting shrinkage of the impression material away from the specimen, because it is adhered to the tray by the adhesive and not to the specimen. This distortion along with differential thickness would result in more distortion.[13] In the same way the mean error values obtained show that closed custom tray impressions were more accurate than open custom tray impressions.

The mean error of sub-groups A and B of Group I (polyvinyl siloxane) were less when compared with the same of Group II (poly ether). These values show that polyvinyl siloxane impressions are better than polyether impressions when used with stock metal trays and closed custom trays. When open window custom tray was used it was observed that polyether impressions are more precise than polyvinyl siloxane impressions. The minimal error observed in the polyether group could be due to the rigidity of the material. This finding is similar to the results of studies conducted by Lin, Cieso.[14,15] It must be noted that the observed difference was not statistically significant. Daovdi, Wee, Barrett also found that there is no difference in the accuracy between polyvinyl siloxane and polyether

impressions.[4,8,9]

In order to achieve a good fitting prosthesis the amount of distortion in the impression phase must be minimized. Keeping this in mind the clinician should select the appropriate technique and the material to suite the clinical situation.

CONCLUSIONS

1. Custom tray impressions were more accurate than stock metal tray impressions.
2. Closed custom tray impressions were better than then open custom tray impressions.
3. Polyvinyl siloxane impressions were more accurate than polyether impressions when stock metal and closed custom trays were used.
4. Polyether impressions made with open custom trays were more accurate when compared to polyvinyl siloxane impressions made with open custom trays.
5. All the six impression techniques studied showed some distortion in transferring the implant positions.
6. Statistically the accuracy of all the impressions techniques was similar.
7. The selection of impression technique and impression material can be based on clinical situation and the clinician's preference.

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