ORIGINAL ARTICLE

Accuracy of impressions with different impression materials in angulated implants

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Abstract

Purpose: To evaluate the dimensional accuracy of the resultant (duplicative) casts made from two different impression materials (polyvinyl siloxane and polyether) in parallel and angulated implants.

Materials and Methods: Three definitive master casts (control groups) were fabricated in dental stone with three implants, placed at equi-distance. In first group (control), all three implants were placed parallel to each other and perpendicular to the plane of the cast. In the second and third group (control), all three implants were placed at 10° and 15° angulation respectively to the long axis of the cast, tilting towards the centre. Impressions were made with polyvinyl siloxane and polyether impression materials in a special tray, using a open tray impression technique from the master casts. These impressions were poured to obtain test casts. Three reference distances were evaluated on each test cast by using a profile projector and compared with control groups to determine the effect of combined interaction of implant angulation and impression materials on the accuracy of implant resultant cast.

Results: Statistical analysis revealed no significant difference in dimensional accuracy of the resultant casts made from two different impression materials (polyvinyl siloxane and polyether) by closed tray impression technique in parallel and angulated implants.

Conclusion: On the basis of the results of this study, the use of both the impression materials i.e., polyether and polyvinyl siloxane impression is recommended for impression making in parallel as well as angulated implants.

Key words: Angulated implants, implant impression, impression accuracy, impression material

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Introduction

In dental implant prosthesis, fabrication of passively fitting prosthesis will lead to the long term success of the restorations.[1] Reproducing the intraoral relationship of implants through impression procedures is the first step in achieving an accurate, passively fitting prosthesis. The critical aspect is to record the 3-dimensional orientation of the implant as it is present intraorally, other than reproducing fine surface detail for successful implant prosthodontics treatment.[2-4] Magnified dissipation of stresses, due to a lack of passivity has been proposed to be associated with mechanical failure of the restorative components, and of the implants themselves, due to peri-implant bone loss.[5,6]

Several studies have been documented in literature regarding the accuracy of impression procedures such as open tray pick-up and closed tray transfer techniques, splinting of impression copings, use of different impression materials, angulation and depth of implants, die material accuracy and master cast realization.[1,7-16] Two impression techniques,

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direct and indirect, are currently used to transfer inter-implant dimensions so that the resultant definitive cast duplicates the clinical condition precisely.[17,18] Research suggests that a direct technique should be used with multiple angulated implants to decrease the distortion.[12] The indirect impression technique can be considered suitable for a parallel or divergent, 2-implant situation.[19] Different impression materials have been examined for use with conventional and implant-supported restorations.[12] Polyether has been the recommended impression material in the past for implant fabrication because of its dimensional stability, rigidity, and tear resistance.[20] Another material frequently used is addition silicone.[21,22] Addition silicone materials present many of the desirable properties of polyether, and with hydrophilic addition silicones, improved wettability and dimensional stability equal to the characteristics of polyether have been observed.[22,23] These silicones may be directly comparable to polyether with respect to the quality of impressions for implant fabrication, at a lower cost. However, there are limited and contradictory reports in the peer-reviewed literature comparing these two impression materials.[12,24-26]

Techniques to achieve more accurate impressions for patients with multiple dental implants are described in the literature. Most of the research has focused on techniques to improve accuracy with parallel implants.[2,7,10,18,27-29] Carr *et al.* evaluated impression methods for nonparallel implants; however, no research was found comparing techniques for implant impressions at varying degrees of divergence or convergence.[17,30]

The purpose of this *in-vitro* study was to analyze the effect of implant angulation and impression material on the accuracy of resultant/duplicative casts by open tray impression technique.

Materials and Methods

The study was conducted to evaluate the dimensional accuracy of the resultant casts made from two different impression materials (polyvinyl siloxane and polyether) by open tray impression technique in parallel and angulated implants.

To determine the effect of combined interaction of implant angulation and impression materials on the accuracy of resultant casts, three master casts were fabricated for three control groups. All three master casts had three implants positioned in a triangular pattern to create a plane. They were numbered as 1, 2 and 3. In first control group, all the three implants were positioned perpendicular to the plane of the cast and parallel to each other at a distance. In the second control group, implants were at an angulation of 10^{o} to the long axis of the cast. In the third control group, implants were at 15^{o} angulation to the long axis of the cast.

Type IV dental stone (Kalrock, die stone class IV, Kalabhai Karson Pvt. Ltd. India) was vacuum spatulated using a mechanical spatulator (Bego vacuum mixer, Bego Bremer Goldschlager will GmBA and Co., Bremen, Germany) and poured into a preformed mold and allowed to set to obtain a master cast. Using an engineering radial drilling machine, 3 implant sites were machined in each master cast in a triangular fashion [Figure 1]. In master cast A, the implant sites were placed parallel to each other and perpendicular to the horizontal plane. In master casts B, the implant sites were machined at an angulation of 10° to the long axis of the cast, tilting towards the centre. In master cast C, the implant sites were machined at an angulation of 15° to the long axis of the cast, tilting towards the centre. Three internal hex implant analogs (ADIN dental implants, Israel), 3.75 mm diameter and 10 mm length were fixed in each of the master cast at the previously drilled sites. Three master casts were labeled and prepared for impression procedures [Figure 2].

Three control groups were formed as follows:
Group 1: Parallel placed Implants.
Group 2: Implants at 10° angulations.
Group 3: Implants at 15° angulations.

The distances between the three implant analogs in each of the master cast were measured using a profile projector (Nikon Profile projector Model V-12; Nikon Corp, Tokyo, Japan) by taking the sharp points of the projected hexagonal silhouette as reference points [Figure 3]. All procedures were completed by the same operator.

Three inter-analog distances were measured on the master casts.

(1) A1/B1/C1: Inter-implant analog distance between implant analog number 1 and 2.

(2) A2/B2/C2: Inter-implant analog distance between implant analog number 2 and 3.

(3) A3/B3/C3: Inter-implant analog distance between implant analog number 3 and 1.

These distances were recorded as A_1 = 26.900 mm, A_2 = 27.900 mm and A_3 = 28.900 mm in master cast A, B_1 = 26.300 mm, B_2 = 26.150 mm and B_3 = 26.000 mm in master cast B and C_1 = 25.350 mm, C_2 = 25.450 mm and C_3 = 25.250 mm in master cast C respectively and were taken as standard for further comparison.

A total of 30 impressions were made using medium bodied vinyl polysiloxane impression material (Aquasil, Dentsply/De Trey) and polyether impression material (Impregum Penta, 3M ESPE, Seefeld, Germany). Ten impressions were made for each group (five each with polyvinyl siloxane and polyether impression material respectively). Custom trays were used to

Figure 1: Radial drilling machine used for drilling the master cast at specified angulation

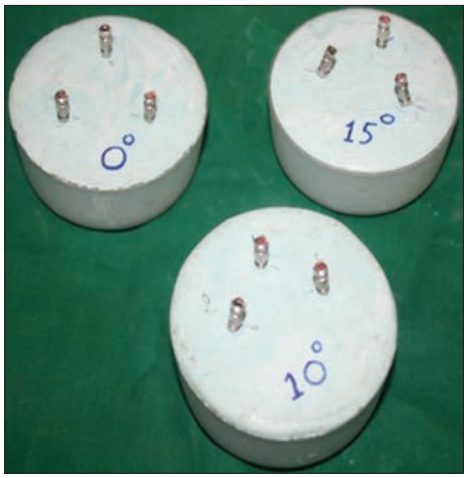

Figure 2: Control groups or master casts with various angulated implants

Figure 3: Profile projector and image of implant analog as seen on the projector screen

make impressions so a total of 30 custom trays were fabricated (10 each for the Master cast A, B and C respectively).[31]

All the impression copings were tightened to the implant analogs on the master casts at 10 Ncm using a torque driver prior to making all the impressions. Before making the impressions, tray adhesive for the polyvinyl siloxane (Universal Tray Adhesive, Zhermack, Italy) and for the polyether (polyether adhesive, 3M ESPE, Germany) was thinly and evenly applied over the inner surface of each tray to extend approximately 2 mm onto the outer surface of the tray along the periphery. The adhesive was allowed to dry before the impressions were made, and the impression was made following the open tray guidelines.[32] Impressions were checked. And thus, a total of fifteen impressions were made with medium-body consistency polyvinyl siloxane impression material and fifteen with the medium body consistency polyether impression material.

Type IV dental stone (Kalrock, die stone class IV, Kalabhai Karson Pvt. Ltd. India) was used to pour these impression and all these resultant casts were stored at room temperature for a minimum of 24 hours before the measurements were made.

A single calibrated examiner blinded to the nature of the impression material and angulation of master cast, examined all the casts to evaluate the positional accuracy of the implant analogs using a profile projector (Nikon Profile projector Model V-12; Nikon Corp, Tokyo, Japan). All the measurements were made under 10× magnifications. The profile projector allowed measurement of linear distances with an accuracy of 0.001 mm (1 um). The distances were measured taking the references of sharp edges of the projected silhouetted form of the analogs. All the three distances were measured for thirty resultant (duplicative) casts and compared with the control group measurements obtained from the three master casts i.e., A_1, A_2, A_3, B_1, B_2, B_3 and C_1, C_2, C_3 for respective groups. All the measurements were subjected to

Statistical analysis

Mean and standard deviation were calculated for each inter-analog distance of duplicative casts of all the groups. The considered variables were the angulation of the implants (Parallel and nonparallel) and the type of impression material (Polyvinyl siloxane and Polyether).

Results

The comparison of mean distances (A1, A2 and A3) of duplicative casts obtained from two impression materials (Polyvinyl siloxane and polyether) with those of master cast A (in which implant analogs were placed parallel) shows non-significant difference [Table 1a,b].

The comparison of mean distances (B1, B2 and B3) of duplicative casts obtained from two impression materials (Polyvinyl siloxane and polyether) with those of master cast B (in which implant analogs were placed at 10° angulation) shows non-significant difference [Table 2a,b].

The comparison of mean distances (C1, C2 and C3) of duplicative casts obtained from two impression materials (Polyvinyl siloxane and polyether) with those of master cast C (in which implant analogs were placed at 15° angulation) shows non-significant difference [Table 3a,b].

No significant difference was recorded in the data obtained.

Discussion

One of the major concerns in implant-retained prostheses is with regard to the accuracy of impressions. This plays an essential role in prosthesis–implant adaptation. An accurate working cast for prosthesis components that have optimal adaptation depends on the impression material as well as the transfer techniques. Furthermore, problems related to investing, casting, alloy properties, and clinician skill should not be neglected. In this study, no significant difference in the dimensional accuracy of the resultant (duplicative) casts, which were made using two different impression materials (polyvinyl siloxane and polyether) and in two different conditions of implants placements, one parallel and other angulated implants.[33,34]

According to Waskewicz *et al.*[35] and Lorenzoni *et al.*,[36] the original implant position and orientation must be reproduced in the working cast so that best prosthesis fit may be achieved without interfering in the path of prosthesis placement. Clinically divergence or convergence between the implants may be often greater than 8° or 10°. When multiple implants are placed with different angles, the distortion of the impression material on removal may increase. Few studies have reported less accurate impressions with angulated implants than with straight implants using an experimental cast with 4 or 5 implants.[12,37] Although polyether has been suggested as the material of choice for implant impression procedures, the use of a more elastic impression material, for example a vinyl polysiloxane material, may hypothetically reduce the permanent deformation of impression material determined by the stress between the material and impression copings created when an impression with the copings is removed from internal connection implants.[14]

Table 1a: Inter-analog distance of master cast, duplicative casts for control group A (parallel placed implants)

Inter-implant analog distance	A1 (mm)	A2 (mm)	A3 (mm)
Master cast	26.900	27.900	28.900
Mean (SD) of duplicative casts from PVS impression material	28.260 (1.37)	29.000 (1.19)	30.590 (1.59)
Mean (SD) of duplicative casts from Polyether impression material	27.570 (2.86)	28.550 (1.34)	29.730 (2.00)

Table 1b: *t*- value (using student's *t*-test) to compare inter-analog distance

Inter-implant analog distance	A1 (mm)	A2 (mm)	A3 (mm)
Between master cast and duplicate casts by PVS impression material	1.98*	1.85*	2.13*
Between master cast and duplicate casts by polyether impression material	0.47*	0.97*	0.50*
Between duplicate casts by PVS and polyether impression material	0.44**	0.50**	0.67**

*(<2.78 for $P = 0.05$) There is no significant difference between the dimensional accuracy of master cast and duplicative casts obtained from both the impression material (polyvinyl siloxane and polyether). **(<2.31 for $P = 0.05$) There is no significant difference between the dimensional accuracy of duplicative casts obtained from polyvinyl siloxane impression material and polyether impression material

Table 2a: Inter-analog distance of master cast, duplicative casts for control group B (Implants placed at 10° angulations)

Inter-implant analog distance	B1 (mm)	B2 (mm)	B3 (mm)
Master cast	26.300	26.150	26.000
Mean (SD) of duplicative casts from PVS impression material	28.470 (2.06)	28.080	28.260
Mean (SD) of duplicative casts from polyether impression material	27.690 (2.33)	27.520	27.430

Table 2b: *t*- value (using student's *t*-test) to compare inter-analog distance

Inter-implant analog distance	B1 (mm)	B2 (mm)	B3 (mm)
Between master cast and duplicate casts by PVS impression material	2.11*	2.12*	1.85*
Between master cast and duplicate casts by Polyether impression material	1.19*	1.20*	1.34*
Between duplicate casts by PVS and polyether impression material	0.50**	0.38**	0.51**

*(<2.78 for $P = 0.05$) There is no significant difference between the dimensional accuracy of master cast and duplicative casts obtained from both the impression material (polyvinyl siloxane and polyether). **(<2.31 for $P=0.05$) There is no significant difference between the dimensional accuracy of duplicative casts obtained from polyvinyl siloxane impression material and polyether impression material

Table 3a: Inter-analog distance of master cast, duplicative casts for control group B (Implants placed at 15° angulations)

Inter-implant analog distance	C1 (mm)	C2 (mm)	C3 (mm)
Master cast	25.350	25.450	25.250
Mean (SD) of Duplicative casts from PVS impression material	28.420 (2.25)	27.890 (2.05)	28.140 (2.16)
Mean (SD) of Duplicative casts from Polyether impression material	27.160 (1.69)	27.200 (1.72)	27.410 (2.39)

Table 3b: *t*- value (using student's *t*-test) to compare inter-analog distance

Inter-implant analog distance	C1 (mm)	C2 (mm)	C3 (mm)
Between master cast and duplicate casts by PVS impression material	2.73*	2.38*	2.68*
Between master cast and duplicate casts by polyether impression material	2.14*	2.03*	1.81*
Between duplicate casts by PVS and polyether impression material	0.89**	0.57**	0.45**

*(<2.78 for P=0.05) There is no significant difference between the dimensional accuracy of master cast and duplicative casts obtained from both the impression material (polyvinyl siloxane and polyether). **(<2.31 for P=0.05) There is no significant difference between the dimensional accuracy of duplicative casts obtained from polyvinyl siloxane impression material and polyether impression material

The distortion of the impression is a concern, in a three dimensional way, in all of the procedures involved in the indirect dental restorations. It can be regarded as absolute or relative, depending on the point of reference from which it is measured, the absolute distortion is considered when the point of reference is external, whereas a relative distortion is measured from a point that is located internal to the system. According to the several studies, in the present investigation, the relative distortion was considered as a study parameter, as the resultant translational distance was measured from one implant analog to another. This kind of measurement can be considered more clinically relevant than the absolute distortion, as implant supported prosthesis usually connects all the abutments to each other.

This study shows that combined interaction of impression material and implant angulation had no effect on the accuracy of the duplicate casts compared to the definitive casts. The results of this study are limited to three implants and may not be relevant for impressions that have higher or lower numbers of implants. Further *in-vitro* and *in-vivo* studies are warranted to fully explore the relative merits of one impression materials over the other and to get to a definite conclusion as to which impression material can be the most accurate in different clinical scenarios pertaining to implant impressions.

Conclusion

Polyvinyl siloxane and polyether impression material have similar dimensional accuracy for transfer procedures in parallel and angulated implants. So on the basis of the results of this study, the use of both the impression materials i.e., polyether and polyvinyl siloxane impression is recommended for impression making in parallel as well as angulated implants.

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