Comparison of Accuracy of Direct Implant Impression Technique using Different Splinting Materials

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ABSTRACT

Introduction: The accuracy of an impression remains critical factor in achieving passive fit of an implant framework. The accuracy of the master cast would depend on the type of impression material, the implant impression technique and accuracy of die material. The different impression techniques advocated in the literature for implant impressions include direct (open tray) and indirect (closed tray) techniques. Direct technique use square impression copings that are picked up in the impressions which were used in this study.

Objective: To evaluate the accuracy of direct impression made with resin splinted and bis-GMA splinted open-tray impression coping. Thus to compare the accuracy of impressions obtained using different splinting materials.

Materials and Methods: A wax mandibular reference model was fabricated and four implants were placed in the mandibular anterior region using surveyor and acrylicized with clear heat cure acrylic resin using injection molding technique. Spaced primary cast was fabricated with a uniform thickness of space about 2 mm. Ten custom trays were fabricated using the light curable resin sheets. Medium body polyether impression material was used. Pentamix was used to get a uniform mix. These trays were randomly divided among the two groups, with five trays in each group. Impression techniques were divided into two groups namely:

Group A—direct impression technique with open tray impression copings splinted with autopolymerizing acrylic resin (GC pattern resin), group B—direct impression technique with open tray impression copings splinted with Protemp TM4 (bis-GMA) syringable temporisation material. Thus, final impressions were made. Total of 10 master casts were fabricated. Evaluation of casts using Dynascope-Vision engineering, Tesa Microhite 2D and coordinate measuring machine were used.

Results: Statistical comparisons were made using ANOVA test and post-hoc test. Same amount of deviation values obtained with resin splinted and bis-GMA splinted impression copings.

The difference in the values might be because of the variation in the rigidity of the materials used.

Conclusion: Both the splinting material exhibit similar accuracy in impression, so bis-GMA can be used, which is easy to handle, less time consuming, less technique sensitive, rigid and readily available material in clinics, instead of resin splinted material which is technique sensitive, more time consuming and cumbersome.

Keywords: Direct impression technique, Resin splinted and bis-GMA splinted.

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INTRODUCTION

The accurate impression making has been emphasized as a significant element in the obtainment of a 'passive fit or optimum fit' between implants and the superstructure. Success in oral rehabilitation is dependent in part, on the accurate registration of those structures that constitute the basis for prosthesis support. An understanding of biomechanics of implant prosthodontics necessitates the fabrication of a passively fitting prosthesis.¹ An inaccurate impression may result in prosthesis misfit, which can lead to further problems such as mechanical and/or biological complications.² Literature shows that the accuracy of the implant cast depends on many factors: the type of impression material, the implant impression technique, the implant angulation, the die material accuracy and the master cast technique.³ Techniques to achieve more accurate impressions for patients with multiple dental implants have been tested.

Among the direct impression techniques, both splinting and nonsplinting have been advocated for accurate impressions. Although splinting with resin, impression plaster or bite registration material has been recommended for maintaining a more accurate interimplant relationship, the accuracy of these techniques in yielding accurate casts is controversial.⁴⁻¹⁶ In order to have rigid and dimensional stable material a newer material bis-GMA was used to splint the impression copings.

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Fig. 1: Finished reference model in heat cure clear acrylic resin

Fig. 2: Spacer adapted to primary cast with impression copings

Fig. 3: Spaced primary cast

Fig. 4: Resin sheet adapted to the spaced primary cast

Paramount importance is to evaluate the accuracy of the impression, in x-, y-, and z-axis using a reliable measuring system. The purpose of this study was to compare the three dimensional accuracy of casts obtained using a splinting technique with different materials and to evaluate the efficacy of autopolymerizing resin and bis-GMA as splinting materials.

MATERIALS AND METHODS

A reference model with four implant analogs (Adin Dental Implant System Ltd, Afula, Israel.) in the mandibular symphyseal region was fabricated in clear heat cure acrylic resin (Triplex, Ivoclar, Vivadent) (Fig. 1). The reference model resembled a mandibular implant-supported overdenture situation. Three stops, one in the anterior and two in the posterior region were made in the land area, this ensures the proper orientation of the impression trays. A primary cast was made using indirect impression technique. In order to obtain uniform spacer, 3 mm even spacer was adapted onto the primary cast (Fig. 2) and the impression made and spaced primary cast was obtained (Fig. 3). Ten custom trays (five per group) with windows in the anterior region were made using light cure acrylic resin sheets Sheet (Plaque Photo, W + P Dental, Hamburg, Germany) of 2 mm in thickness (Figs 4 and 5). To ensure dimensional stability of custom tray, the trays are left

undisturbed for 24 hours prior to impression making. The samples were divided into two groups based on impression technique.

- In group A, the open tray impression copings were screwed to the implant body at 15 Ncm torque. The open tray copings were splinted with dental floss (Oral B Waxed Dental Floss, India). Autopolymerizing resin (GC pattern resin, Osaka, Japan) was mixed in the ratio of 2 gm to 1 ml. When the resin reached the dough stage, it was packed around the impression posts and the dental floss thus they were splinted together. The splint was allowed to polymerize for 4 minutes. The splint was then sectioned in-between the impression posts using a thin separating disk to relieve the stresses caused due to polymerization shrinkage. The cut sections were joined using the same resin by applying it using brush bead method (Fig. 6). This was again allowed to polymerize for 4 minutes. The impression copings, custom tray and the splint were coated with polyether adhesive and allowed to dry for 15 minutes.
- In group B, the procedure of impression making was similar to group A except that instead of pattern resin, bis-GMA (Protemp 4 3M ESPE, India) was used. The shrinkage of the material is lesser than autopolymerizing resin, so the splints were not sectioned

Fig. 5: Finished uniformly spaced custom trays (5 trays per group)

Fig. 6: Reunion of sections by brush bead method

Fig. 7: Syringing bis-GMA temporary crown material

Fig. 8: Application of polyether adhesive

Fig. 9: Completed impression

in-between the impression posts. The bis-GMA (Pro-temp 4 3M ESPE, India) was just syringed using an automix gun (3M ESPE, India) into floss matrix formed between the impression post (Fig. 7). It is allowed to set for about 7 minutes as per the manufacturer's instructions. Once the splinting was rigid then the impression copings, custom tray and the splint were all coated with polyether adhesive (Fig. 8).

The medium body polyether was machine mixed (3M ESPE Pentamix 2, Germany) and dispensed into a penta

elastomer syringe (3M ESPE, Germany). It was syringed around the impression copings to avoid impression defects around the copings and loaded in the custom tray. The tray was then carried onto the reference model immediately and the impression made. It was made sure that the tray seated completely in the three steps that were made in the reference model to ensure complete seating and proper positioning of the custom tray. The impression was allowed to set for 6 minutes as per the manufacturer's recommendation. The screws of the impression posts

Fig. 10: Finished master casts

Fig. 11: Inter-implant distances in x- and y-axis: D1x and D1y — distance between implant/replica 1 and 2 in x- and y-axis respectively, D2x and D2y — distance between implant/replica 1 and 3 in x- and y-axis respectively, and D3x and D3y — distance

were unscrewed and the impression removed from the reference model (Fig. 9). A total of five impressions were made in each group in a similar manner. A total of 10 master casts were obtained (Fig. 10), and only one model was obtained from each impression.

MEASUREMENT PROTOCOL

Dynascope-vision engineering (Tespacalibration centre) was used to measure the x- and y-axes. The magnified image of each implant and implant replica were visualized in the computer and the external margin of each implant and implant replica was taken as reference point. The coordinates of the center of replica 1 was measured and zeroed and kept as (x_0, y_0) . Keeping this as the reference position the centers of the other 3 replica were determined and the linear distance between the centers of implant/

Fig. 12: Inter-implant distances in z-axis: D1z — distance between implant/replica 1 and 2, D2z — distance between implant/replica 1 and 3

replica were all measured in the X and Y planes. Thus, the linear distance between the centers of Replica/implants are 1 and 2 (D1 x/y), 1 and 3 (D2 x/y) and 1 and 4 (D3 x/y) were all measured digitally (Figs 11 and 12).

Tesamicrohite 2D (Tespacalibration centre) is used to find the planes formed by the platform of implant and replica. The probe was used to measure the plane formed by the platform of implant/replica 1 and it was zeroed. The distance between the plane formed by the implant/replica platform, 1 and 2 (D1z), 1 and 3 (D2z) and 1 and 3 (D3z) were measured to get the inter-implant distance in the z-axis (Fig. 13). The angular relationship between the implant/replica to the base of cast were evaluated using a coordinate measuring machine (CMM-TESAMicrohite 3D, TESA Technology). The angle formed between the axis of implant and replica to the base of the model and cast respectively to the horizontal plane.

Fig. 13: Angulation of implants to the horizontal plane

The models were measured 5 times for each reading and the mean value was considered. All the measurements were made by a single operator to avoid inter operator error. The measurements were tabulated and they were statistically analyzed and inference was obtained. A factorial analysis of variance using analysis of variance (ANOVA) was used for statistical analysis and p -value < 0.05 was considered as significant. Post-hoc tests-homogeneous subset gives the difference between the groups based on which subset the group falls.

RESULTS

X-Axis

The difference in inter-implant distance in x-axis ranged from 116 to 16 μ m for impressions with resin splinted copings, 33 to 4 μ m for impressions with bis-GMA splinted copings. The differences in D1x (distance between implant replica 1 and 2), D2x (distance between

implant replica 1 and 3) and D3x (distance between implant replica 1 and 4) for both the test groups were not statistically significant when compared with the reference model values (Tables 1, 2 and Graph 1).

Y-Axis

The difference in inter-implant distance in y-axis ranged from 216 to 180 μ m for impressions with resin splinted copings, 398 to 926 μ m for impressions with bis-GMA splinted copings. Maximum differences were seen in D3y (distance between implant replica 1 and 4) values in group B. A similar trend in dimensional distortion was evident in all the groups except that the amount of distortion varied within the groups (Tables 3, 4 and Graph 2).

Z-Axis

The difference in inter-implant distance in z-axis ranged from 1.1 to 42 μ m for impressions with resin splinted copings, 1.008 to -330 μ m for impressions with bis-GMA splinted copings. The analysis shows that the p -value for the D1z, D2z is less than 0.05 and for D3z is greater than 0.05. Post-hoc range tests show that reference group significantly differ with groups A and B as they fall in different subsets. Both the groups A and B showed differences in similar range (Tables 5, 6 and Graph 3).

Implant Angulation in the Z-Axis to the Horizontal Plane

It plane ranged from -6.78 to -7.21 degrees for the resin splinted group and -3.78 to -5.07 degrees for the bis-GMA splinted group. There was significant difference between the angles (1, 2, 3 and 4) of groups A and B to the reference model (Tables 7, 8 and Graph 4).

Graph 1: Comparison of inter-implant distance in x-axis (values in mm)

Graph 2: Comparison of inter-implant distance in y-axis (values in mm)

Graph 3: Comparison of inter-implant distance in z-axis (values in mm)

Table 1: Comparison of inter-implant distance in x-axis (values in mm)

Groups	D1x		D2x		D3x	
	Mean	SD	Mean	SD	Mean	SD
Reference	9.15	0.00	26.04	0.00	35.84	0.00
Group A	9.26	0.34	26.13	0.36	35.85	0.13
Group B	9.48	0.07	26.34	0.06	35.84	0.13
F statistics	3.52		2.65		0.03	
p-value	0.063		0.111		0.970	

Table 3: Comparison of inter-implant distance in y-axis (values in mm)

Groups	D1y		D2y		D3y	
	Mean	SD	Mean	SD	Mean	SD
Reference	9.95	0.00	9.02	0.00	1.56	0.00
Group A	9.74	0.32	8.81	0.47	1.38	0.58
Group B	9.55	0.12	8.27	0.24	2.49	0.21
F statistics	5.04		7.91		13.97	
p-value	0.026*		0.006**		0.001**	

*Significant at 5%; **Significant at 1%

Table 5: Comparison of inter-implant distance in z-axis (values in mm)

Groups	D1z		D2z		D3z	
	Mean	SD	Mean	SD	Mean	SD
Reference	0.32	0.00	0.62	0.00	-0.30	0.00
Group A	1.43	0.46	1.68	0.65	-0.26	0.51
Group B	1.33	0.13	1.41	0.23	-0.63	0.43
F statistics	24.53		9.61		1.38	
p-value	<0.001**		0.003**		0.290	

*Significant at 5%; **Significant at 1%

DISCUSSION

The overall accuracy of the impression depends on all the four parameters in the x, y, z-axis and angulation of implant/replicas axis to the horizontal plane. The errors in the resin splinting group could be attributed to the minimal shrinkage of the pattern resin used and the technique of splinting. Since the splint was sectioned

Graph 4: Comparison of implant angulation to horizontal plane in z-axis (in degrees)

Table 2: Difference in inter-implant distance in x-axis (values in mm)

Groups	$\Delta D1x$		$\Delta D2x$		$\Delta D3x$	
	Mean	SD	Mean	SD	Mean	SD
A	0.116	0.338	0.084	0.364	0.016	0.131
B	0.330	0.072	0.298	0.054	0.004	0.129

$\Delta D1x$ = D1x of the test group – D1x of the reference model; $\Delta D2x$ = D2x of the test group – D2x of the reference model; $\Delta D3x$ = D3x of the test group – D3x of the reference model

Table 4: Difference in inter-implant distance in y-axis (values in mm)

Groups	$\Delta D1y$		$\Delta D2y$		$\Delta D3y$	
	Mean	SD	Mean	SD	Mean	SD
A	-0.210	0.323	-0.216	0.475	-0.180	0.578
B	-0.398	0.121	-0.752	0.246	0.926	0.208

$\Delta D1y$ = D1y of the test group – D1y of the reference model; $\Delta D2y$ = D2y of the test group – D2y of the reference model; $\Delta D3y$ = D3y of the test group – D3y of the reference model

Table 6: Difference in inter-implant distance in z-axis (values in mm)

Groups	$\Delta D1z$		$\Delta D2z$		$\Delta D3z$	
	Mean	SD	Mean	SD	Mean	SD
A	1.108	0.463	1.060	0.648	0.042	0.505
B	1.008	0.131	0.786	0.228	-0.330	0.433

$\Delta D1z$ = D1z of the test group – D1z of the reference model; $\Delta D2z$ = D2z of the test group – D2z of the reference model; $\Delta D3z$ = D3z of the test group – D3z of the reference model

in between the copings and then reunited, it could have minimized the polymerization shrinkage. Therefore, the amount of resin used for initial splinting could have not influenced the inaccuracy, whereas the dimension of the section made could have influenced the accuracy as it was joined again with resin before making impression.¹⁷ Further research on the dimensions of the splint and the dimensions of the section would shed light on the influence of resin shrinkage on the accuracy of impression. Also, the

Table 7: Comparison of implant angulation to horizontal plane in z-axis (in degrees)

Groups	Angle 1		Angle 2		Angle 3		Angle 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Reference	86.44	0.00	81.46	0.00	81.24	0.00	83.40	0.00
Group A	79.66	2.41	74.25	2.28	73.54	2.67	76.60	2.45
Group B	82.65	2.77	77.68	3.71	76.17	2.34	79.00	2.74
F statistics	12.86		10.30		18.24		13.20	
p-value	0.001**		0.002**		<0.001**		0.001**	

*Significant at 5%; **Significant at 1%

Table 8: Difference in implant angulation to horizontal plane in z-axis (values in degrees)

Groups	ΔAngle 1		ΔAngle 2		ΔAngle 3		ΔAngle 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A	-6.78	2.41	-7.21	2.28	-7.70	2.67	-6.80	2.45
B	-3.79	2.77	-3.78	3.71	-5.07	2.34	-4.40	2.74

ΔAngle 1 = angle 1 of the test group – angle 1 of the reference model; ΔAngle 2 = angle 2 of the test group – angle 2 of the reference model; ΔAngle 3 = angle 3 of the test group – angle 3 of the reference model; ΔAngle 4 = angle 4 of the test group – angle 4 of the reference model

technique of resin splinting has differed among various studies done so far.¹⁸⁻²⁴

Since bis-GMA (Protemp 4) has not been tested for accuracy as a splinting material, data regarding the accuracy of this material for splinting purpose is lacking. Thus the values obtained for this materials in this study have to be compared with the values obtained with the resin splinting group only (since enormous studies had been conducted for the resin splinted copings). The range of differences obtained in bis-GMA splinted group in all the axes were almost in the similar range when compared to the resin splinted group. In x-axis, both the groups A and B exhibits no differences with the reference model. But in y and z-axes and the implant angulation to the horizontal plane, both the groups A and B exhibited significant differences with the reference model in the similar range of difference.

- This preliminary effort to study the accuracy of splinted impression techniques with different splinting materials has yielded positive results especially in relation to the use of bis-GMA (Protemp 4—syringable temporary crown material), further research on the use of this material for splinting purpose might be of use to enhance the accuracy of impression techniques. The results obtained in this study are *in vitro* and so future clinical studies are required to evaluate the effect of intraoral conditions on the materials used for splinting.

CONCLUSION

The following conclusions were arrived within the limitations of this *in vitro* study, which evaluated the accuracy of different direct impression techniques for multiple implants.

- On comparison of the accuracy of implant impressions made by direct technique using resin splinted impression copings and bis-GMA splinted impression copings yielded casts closer to the reference model and within the clinical limits.
- Both the splinting material showed same amount of variation from the reference casts and these splinting materials was statistically similar to each other and falls in same homogenous subsets.
- Thus, both the splinting material exhibit similar accuracy in impression, so bis-GMA can be used, which is easy handling, less time consuming, less technique sensitive, readily available material in clinical and more rigid material, instead of resin splinted material which is technique sensitive, more time consuming and more cumbersome.

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