ORIGINAL ARTICLE

An In Vitro Study to Compare the Accuracy of the Master Cast Fabricated by Four Different Transfer Impression Techniques for Single-Tooth Implant Replacement

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Abstract Single tooth implant retained crowns have become a recognized technique for the replacement of the missing teeth. With the predictable integration of implants, the emphasis is shifted towards precise prosthesis. Minor movement of the impression coping retained inside the impression material can occur during all the procedures, leading to the three-dimensional spatial inaccuracies in the master casts. Therefore, the present study was undertaken with the purpose to evaluate the accuracy of single-tooth implant impression techniques using four different impression copings, so as to obtain a precise definitive cast for a single-unit implant restoration. A maxillary acrylic resin model with a standard single implant in the first molar region was used to simulate a clinical situation. A total of 60 impressions were made with polyvinylsiloxane impression material, which were divided into four groups of 15 impressions each. Group I used non-modified square impression coping, while in group II, III and IV square impression coping were modified differently. Master casts fabricated for all the groups were analyzed to detect rotational position change of the hexagon on the implant replicas in the master casts in reference to the resin model. The master casts obtained with the roughened and adhesive-coated impression copings showed a lower amount of rotational movement than the masters casts achieved with the non-modified impression copings. Hence, the clinician should use sandblasted and adhesive coated impression copings to achieve a more accurate and precise orientation of the implant replicas in the laboratory master casts in single-tooth implant restorations.

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Introduction

Emergence and acceptance of implant dentistry have given clinicians a wide variety of new treatment alternatives for fixed and removable rehabilitation. Implant dentistry has expanded into every aspect of tooth replacement, starting from replacing a missing single tooth, multiple teeth to full mouth rehabilitation. All of these treatment options involve ideology in treatment planning, diagnostic acumen, surgical skills and prosthetic reconstruction techniques [1].

With the predictable integration of implants, the emphasis is shifted towards precise prosthesis [2]. An important factor for success with implant-supported restoration is the passive fit between the superstructure and the abutments. Non-passive prosthesis may result in mechanical and biologic consequences leading to loss of integration and loss of implant. Reproducing the intraoral relationship of implants through impression procedures is the first step in achieving an accurate, passively fitting prosthesis [3]. As Ganz [1] quoted "Proper impression techniques remain as one of the foundations for proper prosthetic reconstruction."

The transfer of exact position and orientation of the single tooth implant to the working casts is particularly important. In case of multiple implants, many technical variations have been suggested to improve the accuracy of the final master casts. When a multiple abutment restoration is fabricated, pick-up impression coping can be splinted together with acrylic resin or composite to stabilize them within the impression material. Similar procedures are not applicable for single-tooth implant replacement, which implies that minor movement of the

impression coping retained inside the impression material can occur during all the procedures, leading to the three-dimensional spatial inaccuracies in the master casts and resulting in a non-passive prosthesis [4].

Therefore, the present study was undertaken with the purpose to evaluate the accuracy of single-tooth implant impression techniques by evaluating the rotational positional changes of the hexagon on implant replicas in laboratory master cast fabricated using impression copings modified in four different ways, and comparing to resin master model, so as to obtain a precise definitive cast for a single-unit implant restoration.

Aim and Objectives

Aim

The aim of the present study was to compare the level of accuracy between the resin model simulating the clinical situation of a maxillary posterior single-tooth implant and four groups of master casts fabricated by four different transfer impression techniques using polyvinylsiloxane impression material.

Objectives

1. To obtain a precise definitive cast for a single-unit implant restoration with external connection implant.
2. To compare the accuracy of the master casts obtained using four different impression copings for single-tooth implant replacement.
3. To study the effect of adhesive application on the external surface of impression coping in obtaining a definitive cast.
4. To study the effect of surface abrasion of the impression coping in obtaining a definitive cast.
5. To study the effect of roughening the external surface of impression coping followed by application of a tray adhesive in obtaining a definitive cast.

Materials and Method

An acrylic resin dentulous model of maxillary arch with an external connection 5.0 × 10.5 mm implant (BioHorizons Implant System, USA) in the right first molar edentulous region was used to simulate a clinical situation (Fig. 1). The second molar distal to the implant and the second premolar mesial to the implant were cut in a buccopalatal direction using a carborundum disc mounted on laboratory straight handpiece to obtain two reference planes for the measurement of the angles between one of the side of the

implant hexagon serving as the first plane and the sectioned tooth serving as the second plane. Thus two angles, one formed by the molar plane and the distopalatal side of the implant hexagon (MIA) and the other formed from the pre-molar plane and the mesiopalatal side of the implant hexagon (PIA), were obtained (Fig. 2).

Close fit, rigid custom trays with a window to allow access for the direct pick up coping were fabricated and were coated with manufacturer recommended impression adhesive 5 min before the impressions were made. Before every impression, an impression coping (BioHorizons Implant System, USA) was secured to the implant on the resin model. Polyvinylsiloxane impressions were made according to the manufacturer's directions using one-step method of impression making. The heavy consistency polyvinylsiloxane impression material (Affinis, Coltene Whaledent) was loaded inside the impression tray and light consistency polyvinylsiloxane impression material (Affinis, Coltene Whaledent) was meticulously syringed around the impression coping to ensure complete coverage of the coping. The impression tray was then lowered over the reference resin model until the tray was fully seated and maintained in position throughout the polymerization time.

A total of 60 impressions were made which were divided into four groups (Fig. 3) of 15 impressions each:

Group I	Using non-modified square impression coping
Group II	Using square impression coping modified by coating with recommended adhesive for polyvinylsiloxane impression material
Group III	Using square impression coping sand blasted using clean 50 μm aluminium oxide powder at 2.5 atmospheres
Group IV	Using square impression coping sand blasted using clean 50 μm aluminium oxide powder at 2.5 atmospheres, followed by coating with recommended adhesive for polyvinylsiloxane impression material

Fig. 1 Acrylic maxillary dentulous model with implant in the first molar region
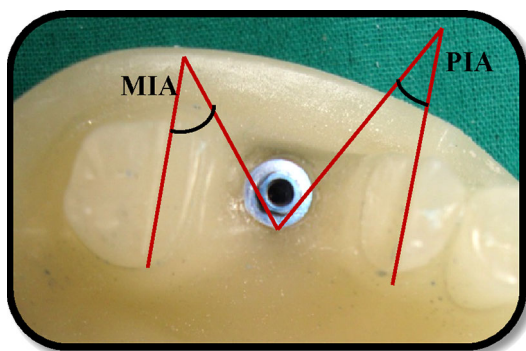
Fig. 2 Reference resin model with angles MIA and PIA

Impression material was allowed to set for 10 min from the start of mixing to compensate for the delayed polymerization time at room temperature. After the impression material had set, the coping screw was loosened and the tray removed with the transfer coping retained in them (Fig. 4). 24 h later, the implant replica (BioHorizons Implant System, USA) was screwed onto the transfer coping retained within the impressions and poured using type IV dental stone (Elite Rock, Zhermack Technical)

following manufacturer's instructions. The casts were retrieved from the impressions after 2 h. All casts were stored at room temperature for a minimum of 24 h before measurements were made. All clinical and laboratory procedures were performed by the same operator.

Measurements and Statistical Analysis

A single calibrated examiner blinded to the nature of the impression technique used, examines all definitive casts to evaluate the rotational accuracy of the implant replica heads using a profile projector. The two angles formed by the molar plane and the distopalatal side of the implant hexagon (MIA) and the premolar plane and the mesiopalatal side of the implant hexagon (PIA) in the resin model and the 60 master casts in group I, II, III and IV were measured using the profile projector (Fig. 5).

Rotational movements of the impression coping inside the impression material in groups I, II, III and IV were assumed to result in angular variations between the resin model and the stone master casts. Therefore the differences in degrees between the angles MIA and PIA

Fig. 3 Different groups of impression technique (a) Group I: Non modified square impression coping (b) Group II: Adhesive coated square impression coping (c) Group III: Sand blasted square impression coping (d) Group IV: Sand blasted and adhesive coated square impression coping
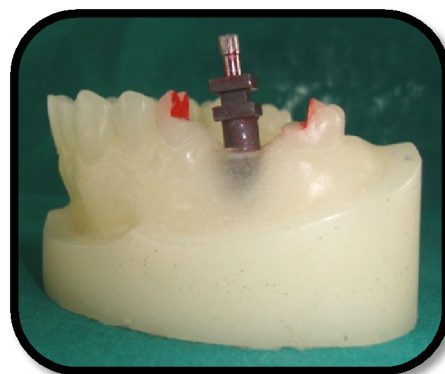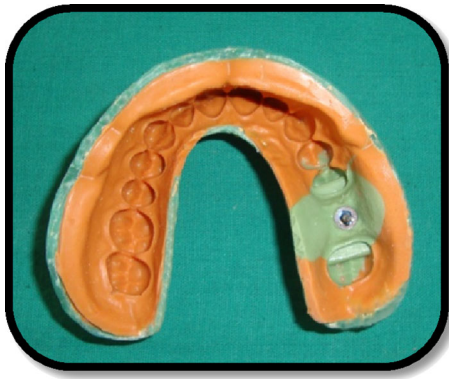

a

b

c

d

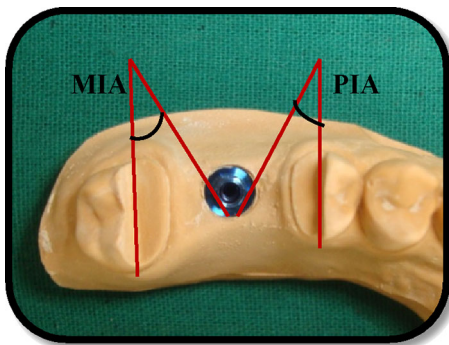**Fig. 4** Open tray impression with pick-up coping

Fig. 5 Master cast showing reference molar and premolar planes and angles formed by molar plane and distopalatal side of implant hexagon (MIA) and premolar plane and mesiopalatal side of implant hexagon (PIA)

measured on the reference resin model and the equivalent angles measured on the 60 master casts were analyzed statistically to determine which group produces more accurate impressions.

Results

The molar plane angle (MIA) was found to be 24.9836° and the premolar plane angle (PIA) was 28.9017° in the resin master model. This was used as the reference against which the angles formed by the master cast in the respective groups were compared.

The difference in the MIA from the resin master model to the mean of the samples were 49 min 48 s on group I casts; 37 min 41 s on group II casts; 37 min 26 s on group III casts; and 21 min 38 s on group IV casts. For the PIA, the difference from the resin master model were 1° 6 min 45 s on group I casts, 58 min 2 s on group II casts, 53 min 41 s on group III casts, and 26 min 31 s on group IV casts (Table 1).

Comparison of the mean of molar plane angles (MIA) and premolar plane angles (PIA) of all the four groups

revealed no significant statistical difference between the non-modified group (group I) and modified groups (groups II, III and IV). In this study $p = 0.05$ was considered as the level of significance (Table 2).

Further comparison of the coefficient of variation showed that group IV had the least amount of variation. The observed values for MIA were 12.45, 9.19, 8.18 and 4.65 %; and for PIA were 9.56, 7.87, 7.77 and 5.37 % for groups I, II, III and IV respectively (Table 3).

One-way ANOVA had not revealed any significant differences for both the molar plane angle (MIA) and the premolar plane angle (PIA) between the definitive casts obtained from the groups I, II, III and IV (Table 4).

Discussion

The objective of this in vitro study was to evaluate the effect of surface roughening and coating of tray adhesive on square pick-up impression coping before the final impression procedure on the orientation of the external hexagon of implant to the working cast in case of the single-tooth replacement.

Although the means of the angles MIA and PIA were not significantly different between groups I, II, III and IV, comparison of the standard deviations and variances revealed that surface roughening followed by coating of the square impression coping with adhesive (group IV) yielded more precise master casts in which the spatial orientation of the hexagon head of the implant replica corresponded closely to the hypothetical intraoral spatial position of the implant head (Graphs 1, 2, 3, 4).

When comparing ranges, the maximum angular variation obtained for MIA in group IV was 1° 52 min 7 s while in group I was 4° 51 min 8 s. For PIA the maximum variation was 2° 43 min 16 s for group IV while 5° 42 min 17 s for group I. This shows that the amount of rotational movement of implant components had considerably decreased from group I to group IV. Hence it can be assumed that the sand blasting of the square impression coping followed by coating of adhesive for polyvinylsiloxane impression material as in group IV have an edge over the nonmodified copings in group I and other modifications of copings in group II and III.

The present study suggests the coating of the sand blasted impression coping with adhesive in the impression phase for single-tooth restorations to improve the accuracy of the final master casts. This is in agreement with the previous studies [4, 5] where impression was found to be more accurate when square impression copings were air borne particle abraded and coated with adhesive. Theoretically, air borne particle abrasion and adhesive coating of the impression copings should decrease the degree of

Table 1 Mean molar plane angles (MIA) and premolar plane angles (PIA) measured on the definitive casts of different groups

	Mean molar plane angle (MIA) (°)	Mean premolar plane angle (PIA) (°)
Resin master model	24.9836	28.9017
Group I	24.1535 ± 3.0085	27.7892 ± 2.6569
Group II	24.3555 ± 2.2378	27.9345 ± 2.1994
Group III	24.3598 ± 1.9919	28.0070 ± 2.1755
Group IV	24.6231 ± 1.1457	28.4597 ± 1.5285

Table 2 Comparison of the molar plane angle (MIA) and premolar plane angle (PIA) of the resin master model with the sample mean angles of the four study groups

		Resin master model	Mean ± SD	t value	p value	Inference
MIA	Group I	24.9836°	24.1535° ± 3.0085	1.064	0.305	NS
	Group II		24.3555° ± 2.2378	1.081	0.298	NS
	Group III		24.3598° ± 1.9919	1.206	0.248	NS
	Group IV		24.6231° ± 1.1457	1.207	0.248	NS
PIA	Group I	28.9017°	27.7892° ± 2.6569	1.619	0.128	NS
	Group II		27.9345° ± 2.1994	1.700	0.111	NS
	Group III		28.0070° ± 2.1755	1.590	0.134	NS
	Group IV		28.4597° ± 1.5285	1.166	0.283	NS

Table 3 Comparison of the molar plane angle (MIA) and premolar plane angle (PIA) variations within different study groups
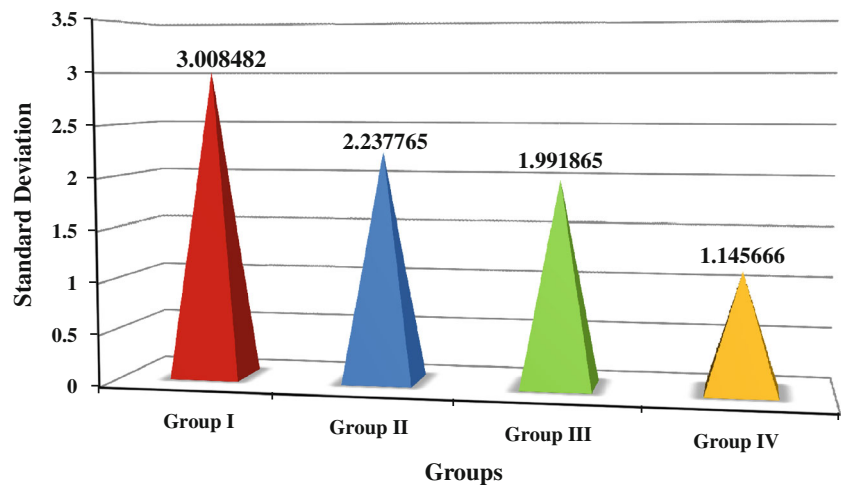
		Resin master model	Mean ± SD	CV (%)
MIA (°)	Group I	24.9836°	24.1535° ± 3.0085	12.454
	Group II		24.3555° ± 2.2378	9.189
	Group III		24.3598° ± 1.9919	8.178
	Group IV		24.6231° ± 1.1457	4.653
PIA (°)	Group I	28.9017°	27.7892° ± 2.6569	9.558
	Group II		27.9345° ± 2.1994	7.872
	Group III		28.0070° ± 2.1755	7.768
	Group IV		28.4597° ± 1.5285	5.371

Table 4 One-way ANOVA of molar plane angles (MIA) and premolar plane angles (PIA) measured on the definitive casts obtained with four different impression techniques
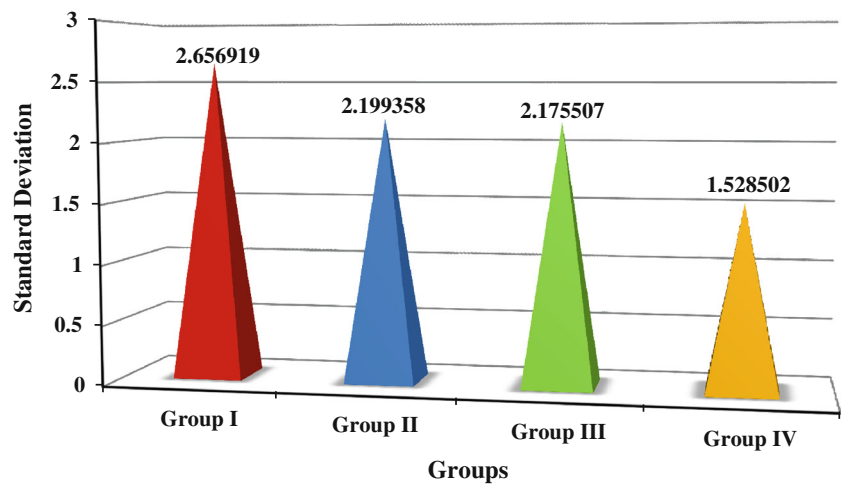
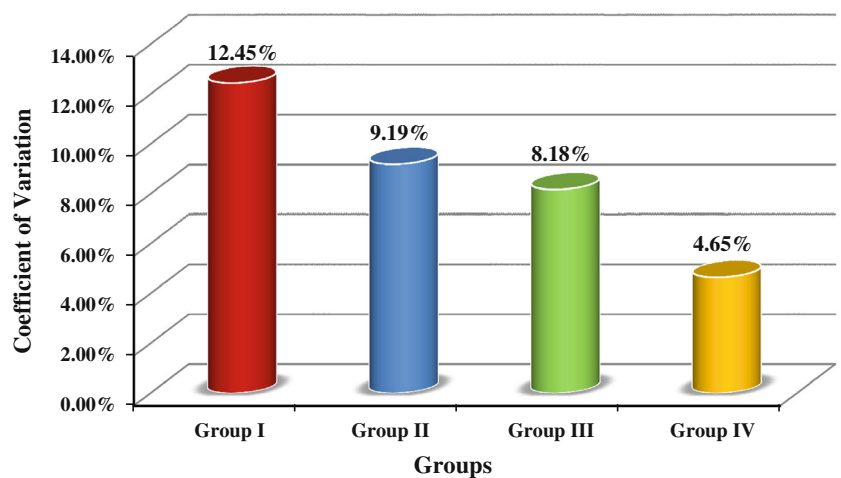|		N	Mean ± SD	F value	p value
MIA (°)	Group I	15	24.1535° ± 3.0085	0.115	0.951[*]
	Group II	15	24.3555° ± 2.2378		
	Group III	15	24.3598° ± 1.9919		
	Group IV	15	24.6231° ± 1.1457		
PIA (°)	Group I	15	27.7892° ± 2.6569	0.265	0.851[*]
	Group II	15	27.9345° ± 2.1994		
	Group III	15	28.0070° ± 2.1755		
	Group IV	15	28.4597° ± 1.5285		

[*] Non significant

Graph.1 Comparison of standard deviation of molar plane angle (MIA) between different study groups

Graph.2 Comparison of standard deviation of premolar plane angle (PIA) between different study groups
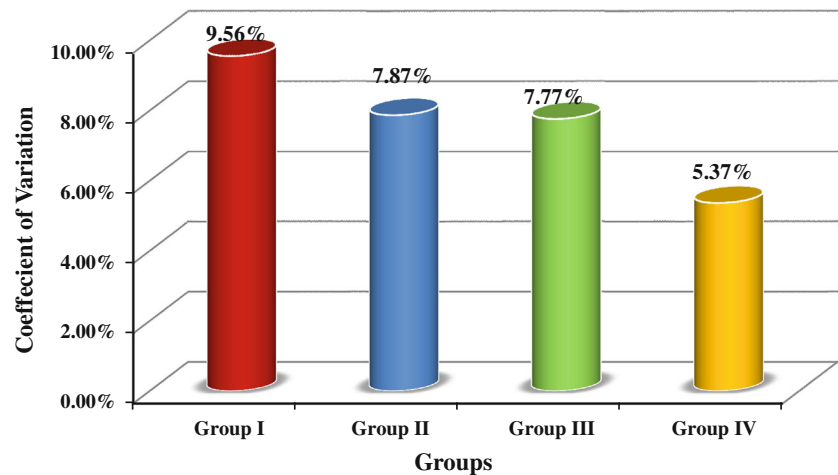

Graph.3 Comparison of the molar plane angle (MIA) variations within different study groups

micro movement of the copings inside the impression material from impression making to impression pouring. This may be due to the intimate contact between the impression material and impression coping resulting from roughening the external surface of impression copings to increase the surface area and then applying a coating of impression adhesive for adhesion of impression coping inside the impression material. This in turn will result in more accurate orientation of the implant replicas in the laboratory master cast and thus less time consuming chair

Graph.4 Comparison of the premolar plane angle (PIA) variations within different study groups

side modifications and adjustments of the single-tooth crown [5].

Possible limitations of the present study design were that the measured distortions did not completely evaluate the actual three-dimensional distortion of the impressions. Only the discrepancies in axial rotations of the components were detected. Under clinical conditions these differences may vary if the discrepancies are present in other spatial planes. Thus, such discrepancies may clinically result in an improper fit of the prosthesis.

So further studies may be required to evaluate the clinical relevance of the three dimensional movements of impression copings inside the impression material.

Conclusion

Within the limitations of this study, the following conclusions were drawn:

1. With respect to comparison of variability, based on standard deviation and coefficient of variation, master casts obtained with the roughened and adhesive-coated impression copings showed a lower amount of rotational movement than the masters casts achieved with the nonmodified impression copings relative to the position of the hexagon head of the implant on the reference resin model.

2. The master casts obtained from the sandblasted and adhesive coated square impression coping technique accurately reproduced the spatial orientation of the hexagon head of the implant as present in the resin master model thus will result in less time consuming chairside modifications and adjustments.

Further clinical investigations will be necessary to confirm the results of the present in vitro study.

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