Comparison of Different Impression Techniques When Using the All-on-Four Implant Treatment Protocol

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Purpose: The aim of this in vitro study was to compare the accuracy of two different impression techniques for the All-on-Four implant therapy protocol. ***Materials and Methods:*** An acrylic resin analog for an edentulous maxilla with four internal connection implants (Replace Select, Nobel Biocare) was fabricated according to the All-on-Four protocol. A total of 40 impressions were made with different techniques (open and closed tray) at abutment and implant levels and poured in type IV dental stone. A coordinate measuring machine was used to record the x, y, and z coordinates and angular displacement. The measurements were compared with those obtained from the reference model. Data were analyzed with analysis of variance and *t* test at $\alpha = .05$. ***Results:*** There was less linear and rotational displacement for the open-tray technique when compared with the closed-tray technique ($P = .02$ and $P < .001$, respectively). Impressions made at abutment level produced fewer linear and rotational displacements when compared with implant-level impressions using the open-tray technique for straight and angulated implants ($P = .04$ and $P < .001$, respectively). However, less rotational dislocation was observed for impressions made with the closed-tray technique when compared with the open-tray technique at implant level ($P < .001$). ***Conclusion:*** Choice of impression technique affected the accuracy of impressions, and less displacement was observed with the open-tray method. Abutment-level impressions with an open-tray technique were more accurate, while implant-level impressions were more accurate when a closed-tray technique was used. *Int J Prosthodont 2016;29:265–270. doi: 10.11607/ijp.4341*

Optimal implant prosthodontic therapy demands accurate impressions to ensure passivity of fit between abutments and the superstructures they support.[1–14] The recent introduction of the All-on-Four protocol aims to provide prosthetic superstructure support on four implants that are widely spaced and often angulated in different directions.[6,11,13] Impression registrations for patients undergoing this form of implant therapy may be done at either the implant or the abutment level, using either open- or closed-tray designs, as described and assessed by several authors.[6,8,11,13] However, the specific All-on-Four approach poses technical intraoral challenges when compared with traditional clinical management of location of several implants in the anterior zone of edentulous arches. This in vitro study compares open-tray and closed-tray impression techniques in laboratory simulation of a treated All-on-Four edentulous maxilla. The null hypothesis was that there would be no significant difference in the transfer accuracy of different angulations of implants from the reference model to the definitive casts using two impression techniques at two different levels.

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Materials and Methods

A reference acrylic resin replica of an edentulous maxilla was made. The proposed All-on-Four protocol was followed, and four regular platform implants (Replace Select; Nobel Biocare), each 4.3 mm in diameter and 13 mm in length, were inserted in canine and second premolar sites using the prescribed All-on-Four guide (All-on-4, Nobel Biocare). Two anterior implants were inserted perpendicular to the horizontal plane and parallel to each other, while the angulation

Table 1 Absolute Mean Values (Standard Deviation) of the Recorded Measurements and Comparisons Among All Groups

Impression level	Impression technique	Straight Δr (μm)	Angulated Δr (μm)	*P*	Straight Δθ (°)	Angulated Δθ (°)	*P*
Implant							
Group 1	Open	0.121 (0.114)	0.182 (0.201)	.245	7.13 (1.028)	33.54 (2.861)	.001
Group 2	Closed	1.21 (0.67)	0.523 (0.72)	.003	8.84 (7.85)	1.92 (1.71)	.000
Abutment							
Group 3	Open	0.125 (0.098)	0.227 (0.169)	.026	2.018 (1.428)	3.03 (1.99)	.073
Group 4	Closed	1.731 (0.98)	0.79 (0.678)	.001	12.822 (6.406)	24.26 (1.61)	.067

of two posterior implants was angled 45 degrees to the distal. All these fixtures were secured with autopolymerizing acrylic resin (Technovit 4000, Heraeus Kulzer) 24 hours before impressions were made. A metallic index was inserted in the midline of the palate to serve as a reference for measurement and was defined as point zero (Fig 1).

Classification of groups is presented in Table 1. Four multiunit abutments (Nobel Biocare) were screwed into the implants on the model for groups 3 and 4. Anterior abutments were straight, and posterior were at a 30° angle (Fig 2a). Straight abutments were torqued to 35 Ncm, and angulated were torqued to 15 Ncm, according to the manufacturer's recommendations.

After 24 hours, the impression copings (Nobel Biocare) were secured to the implants and abutments (Fig 2b). Base-plate wax (Modeling Wax, Dentsply DeTrey) was added around and over the impression copings, and two irreversible hydrocolloid (Alginoplast, Heraeus Kulzer) impressions were made. These casts were covered by two layers of base-plate wax (Modeling Wax, Dentsply) to provide a uniform thickness of impression material. Tissue stops were made for accurate tray positioning during impression making. Forty 2-mm-thick custom impression trays (20 open and 20 closed) were made of light polymerizing resin (Megatray, Megadenta). Internal surfaces and 5 mm beyond the borders of all perforated impression trays were coated with adhesive (Universal Adhesive, 3M ESPE) 30 minutes before impression making. An addition silicone (Elite HD+ Regular Body, Zhermack) was used for all impressions and was handled according to the manufacturer's recommendations. The impression-making procedure was conducted in a temperature-controlled environment (23 ± 1°C) with a relative humidity of 50 ± 10%.

In groups 1 and 3, square copings (Fig 3a), and in groups 2 and 4, conical copings (Fig 3b) of Nobel Replace implants system (Nobel Biocare) were fastened to the implants and abutments, respectively, with a torque wrench calibrated at 10 Ncm torque.[15] The impression material was mixed using an automixing cartridge. For each impression, some of the impression material was carefully injected around and over the impression copings to cover them completely. The remaining impression material was used to load the impression tray. The impression tray was lowered over the reference resin model until seating on the location marks, and a 5-kg weight was placed over the tray. According to the manufacturer's recommendation, the impression materials were left to polymerize for 12 minutes after impression mixing. The impressions were placed in distilled water at 36 ± 1°C during the setting time.

After removal of the impressions, implant or abutment analogs were fitted and fastened into the pick-up impression copings. In groups 2 and 4, the impression/matrix set was separated.

After conical impression copings were unscrewed from the matrix and adapted to their corresponding analogs, they were immediately inserted in their respective notches in the impression to full depth and then slightly rotated clockwise to feel for the antirotational resistance.[5,6] The casts were then made using type IV dental stone (Herostonel Vigodent) after vacuum mixing with a powder/water ratio of 30 g/7 mL, according to the manufacturer's recommendation. After 120 minutes from pouring, the impression was separated from the cast. The whole procedure was done by the same operator (S.R.).

All readings of the casts were done randomly by a single calibrated blinded examiner. To record displacement in the x, y, and z directions and rotational discrepancies, a coordinate measuring machine (CMM) (Mistral, DEA Brown & Sharpe) with an accuracy of 2.8 μm was used.[5,6,13] After measuring each cast three times, a mean value was obtained for every sample. The distances from the reference point on the center of the superior surface of each cast were compared with the reference model (Fig 4). Readings were also executed in all four implants of the reference model (abutment and implant level). A 1-mm-wide straight CMM probe recorded

Fig 1 Reference model of edentulous maxilla with four Nobel Replace implants (groups 1 and 2).

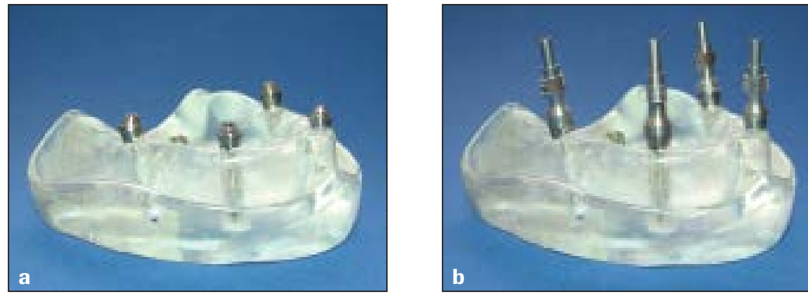

Fig 2 **(a)** Low-profile straight (for anterior implants) and angled (for distally tilted implants) abutments attached to the implants (groups 3 and 4). **(b)** Abutment-level square impression copings.

the distance between centers of the implant aperture in each direction (x, y, and z) and the perpendicularity of each implant in comparison with the horizontal plane of the central reference point in the casts/model. Angular changes (Δθ) were measured using the flat side of the impression copings or abutment analogs as reference for measuring the rotations. Displacement, Δr, was calculated using $\Delta r^2 = \Delta x^2 + \Delta y^2 + \Delta z^2$, which represents the displacement in three-dimensional space. These linear and angular measurements were conducted for the reference model and the definitive casts.

The data obtained from the readings were recorded and tabulated. Means and standard deviations were calculated and submitted to analysis of variance with three variables: impression technique (open and closed), impression level (abutment and implant), and implant angulation (straight and angulated) at a significance of 5% ($P < .05$). After differences were detected among the groups, *t* test was applied.

Results

The measurements of angular dislocation (Δθ) and Δr are shown in Table 2. There was a significant difference between straight and angulated, implant level and abutment level, and open-tray and closed-tray techniques.

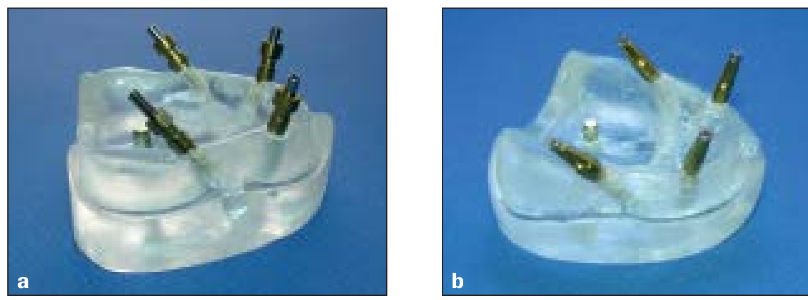

Fig 3 **(a)** Implant-level open impression coping. **(b)** Implant-level closed impression coping.

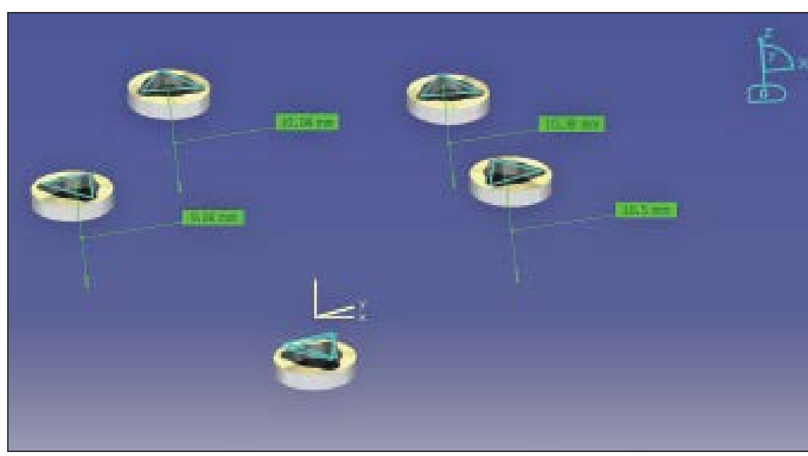

Fig 4 Schematic drawing of the measurements according to the reference point. The measurements were done in x, y, and z directions, and rotational displacement was also measured.

Table 2 The Effect of Interaction Between Impression Technique and Impression Level by Comparing the Inaccuracy Values for Straight and Angulated Implants

	P			
	Straight implants		Angulated implants	
Impression level/technique (group)	Δr	Δθ	Δr	Δθ
Open tray (1, 3)	.895	.040	.450	.000
Closed tray (2, 4)	.057	.087	.235	.000
Implant level (1, 2)	.060	.558	.53	.051
Abutment level (3, 4)	.000	.000	.02	.000

Implant Angulation Effect

Based on the results obtained, implant angulation had a significant effect on the linear and rotational accuracy of impressions made at the implant level, except for open-tray technique for Δr ($P > .05$). Using closed-tray technique, straight implants showed less linear and rotational displacement (1.21 μm and 8.84 degrees, respectively) compared with angulated implants (0.52 μm and 1.92 degrees, respectively). Straight implants also had less rotational inaccuracy (7.13 degrees) in comparison with angulated implants (33.54 degrees) using open-tray technique. Impressions made at abutment level using open-tray and closed-tray techniques were only significantly different for straight and angulated implants in terms of linear displacement ($P > .05$) (Table 1). In this regard, while straight implants showed less dislocation (0.12 μm vs 0.22 μm) using open-tray technique, angulated ones delivered more accuracy (0.79 μm vs 1.73 μm) with use of the closed-tray technique.

Impression Level and Impression Technique Effects for Straight Implants

Comparison between implant-level and abutment-level impression techniques showed that abutment-level technique produced less linear displacement with use of square impression copings (2.01 degrees vs 7.13 degrees) ($P = .04$). Also, open-tray technique showed more linear and rotational accuracy than closed-tray technique for abutment-level impressions (0.12 μm vs 1.73 μm, and 2.01 degrees vs 12.82 degrees, respectively) ($P < .001$) (Table 2).

Impression Level and Impression Technique Effects For Angulated Implants

According to the results, abutment-level impressions delivered more rotational accuracy than implant-level impressions using open-tray technique (3.03 degrees vs 33.54 degrees) ($P < .001$). However, there was less rotational dislocation for impressions made at implant level as compared with abutment-level impressions using closed-tray technique (1.92 degrees vs 24.26 degrees) ($P < .001$). Also, there was less linear and rotational displacement for open-tray technique than for closed-tray technique at abutment level (0.22 μm vs 0.79 μm, and 3.03 degrees vs 24.26 degrees, respectively) ($P = .02$ and $P < .001$, respectively) (Table 2).

Discussion

The findings in the present study did not support the null hypothesis, since all three factors tested (implant angulation, impression level, and technique) had significant effects on the accuracy of the definitive casts. Straight implants showed less linear and rotational discrepancy when compared with angulated ones using square impression copings at implant or abutment level. On the other hand, the closed-tray technique showed greater accuracy for groups with angulated implants at implant or abutment level. Other studies that evaluated the effect of implant angulation also cited implant angulation as an accuracy determinant.[1,6,10,12]

Ehsani et al[13] reported no significant difference in the accuracy of impressions made of two implants tilted 30 degrees distally in the All-on-Four protocol using an open-tray technique. Moreover, they reported that a 45-degree angulation did not necessarily result in a less accurate impression, observations in which choice of impression material could have played a role. Impression material characteristics may certainly influence outcome accuracy, and the selected material for this study—addition silicone—has a lower modulus of elasticity than polyether and yet has enough rigidity.[14] It is believed that when nonparallel implants are present, a less stiff material would be more suitable for easy removal of the impression.[4,8]

The results of this study also showed that the levels at which impressions are made may significantly affect the accuracy of the definitive casts, and a correlation between impression technique and impression level was observed. This might be related to the differences in length, shape, and geometry of abutment-level and implant-level impression copings used for open-tray and closed-tray techniques. Implant-level impressions showed better results than abutment-level impressions when closed-tray technique was used, as noted in other reports.[5,6]

Alikhasi et al[5] suggested that impressions made at implant level were more accurate than abutment-level impressions, and cited the accuracy of metal copings used for implant-level impressions compared with the plastic copings used for abutment-level impressions. However, in the present study metal components were used for all impressions. The implant-level impression technique presents some advantages over abutment-level technique, which include facilitation of abutment selection in the laboratory, enabling use of customized abutments, and easier temporization procedure.[2] In the present study, open-tray impressions made at the abutment level were associated with less inaccuracy than implant-level ones as well. This observation contrasts a report[6] that showed more angular accuracy for implant-level impressions. Angulated abutments could have compensated for the angulation of distally located abutments compared with using implant-level impression copings in the open-tray technique with external connection implants.

Another factor that influenced the accuracy of the impressions was the impression technique (open tray vs closed tray). The open-tray technique showed fewer linear and angular displacements for straight or angulated implants. This finding is in agreement with other studies that showed the open-tray technique was more accurate than the closed-tray one.[3,4,6] Moreover, leaving the square impression copings in the impression reduces the effect of the implant angulation and the deformation of the impression material on removal from the mouth.[9] This inaccuracy is accentuated in the presence of nonparallel implants.[3,10]

One of the advantages of this study is the use of a laboratory edentulous analog. Although this selection may not necessarily contain excessive anatomical undercuts, it simulates the strain generated during impression removal more effectively than smooth and flat block. However, the path of tray removal was perpendicular to the implants' horizontal plane, which does not simulate the clinical situation; this, too, could affect impression accuracy. Furthermore, differences in published reports on the accuracy of different impression techniques might be attributable to the measurement method.[7] One of the advantages of this study is the use of a very precise three-dimensional measuring device for recording possible implant replica displacements in three axes, although only reported rotational and linear displacements, which are more clinically relevant and easier to comprehend, were recorded. It should also be noted that the standard deviations of some groups were of the same order of magnitude as the mean distortion. This deviation might be due to factors such as machining tolerance of implant components, impression material contraction, errors related to technique and operator, and expansion of investment.[7]

A limitation of this study is the number and degree of angulation of the implants placed according to the All-on-Four protocol. The results of this study are limited to four implants with such arrangements and might not apply to impressions with higher or lower numbers and different degrees of implant divergence. Furthermore, it might be assumed that tissue undercuts and different implant angulations may cause greater inaccuracy in the impression procedures that were not addressed in the present study. Further study is needed to evaluate the effect of different implant angulations and numbers, impression materials, and depths of implant insertion, and the effect of splinting on the accuracy of impressions.

Conclusions

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

1. Straight implants showed better results than angulated implants using open- or closed-tray technique for abutment-level impression.
2. Angulated implants were more accurate using the closed-tray technique at implant level when compared with straight implants.
3. Abutment-level impressions showed less rotational displacement when using the open-tray technique for straight or angulated implants.
4. The open-tray technique was more accurate than the closed-tray one for impressions made at abutment level for straight or angulated implants.
5. In general, abutment-level impressions made with open trays showed more linear and rotational accuracy when used in the All-on-Four simulated protocol. This could be the result of using angulated abutments for two distal angulated implants, which brought them into a straighter state as compared with implant-level impression. Also, retaining the abutments in the impression for the open-tray technique would eliminate inaccuracies produced by incorrect insertion of the abutment/analog set in the impression.

Acknowledgments

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Literature Abstract

Immune Dysregulation Mediated by the Oral Microbiome: Potential Link to Chronic Inflammation and Atherosclerosis

There are many studies associating oral health and cardiovascular disease, but others refute the link. This timely review examines potential mechanisms to explain how periodontal pathogens may elicit immune dysregulation leading to progressive inflammation manifesting as atherosclerosis. The host inflammatory response to commensal organisms causes the destruction of supporting periodontal tissues. Atherosclerosis starts with dysfunctional endothelium, recruitment of immune cells, and progressive inflammation. The exact immune mechanisms resulting in atheroma formation are unknown, but potential direct and indirect mechanisms have been proposed. Direct mechanisms include presence of *P gingivalis* in atheroma, possibly transported by host immune cells and disruption of endothelial cell function by oral bacteria. Indirect mechanisms include alteration of oral and hence gut microbiota leading to increased permeability and proinflammatory cytokine production. Future therapies must balance the role of inflammation in clearing infection with immune activation causing unresolved inflammation.

Slocum C, Kramer C, Genco CA. *J Intern Med.* Epub ahead of print 21 Jan 2016. **doi:** 10.1111/joim.12476. **References:** 115. —*Steven Soo, Singapore.*