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Comparison of the accuracy of open-tray and snap-on impression techniques of implants with different angulations

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ABSTRACT

Background: A precise transfer of the position of an implant to the working cast is particularly important to achieve an optimal fit of the final restoration. Different variables affect the accuracy of implant impression. The purpose of the present study is to compare the accuracy of open-tray and snap-on impression techniques in implants with different angulations.

Materials and Methods: In this experimental study: A reference acrylic resin model of the mandible was fabricated. Four implants were positioned with the angles of 0°, 10°, 15°, and 25° in the model. Ten impressions were prepared with open-tray technique and ten impressions were made using snap-on technique. All impressions were made from vinyl polysiloxane impression material. Linear (Δx, Δy, and Δr) and angular displacements ($\Delta\theta$) of implants were evaluated using a coordinate measuring machine. Measured data were then analyzed using two-way analysis of variance and Tukey's test ($\alpha = 0.05$).

Results: The results showed that the accuracy of open-tray impression technique is significantly different from snap-on technique in Δx ($P = 0.003$), Δy ($P = 0.000$), Δr ($P = 0.000$), and $\Delta\theta$ ($P = 0.000$). Implants with 25° angulation are significantly less accurate than 0°, 10°, and 15° implants in Δx, Δy, Δr, and $\Delta\theta$. Fifteen-degree implants are less accurate than 0° and 10° ones in $\Delta\theta$.

Conclusion: Regarding the findings of this study, it can be concluded that snap-on technique is less accurate than open-tray technique, and the accuracy of 25° implant is less than that of 0°, 10°, and 15° implants.

Key Words: Accuracy, dental implants, dental impression techniques

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INTRODUCTION

A critical requirement for a long-term implant success is an accurate and passively fitting prosthesis in dental implant prosthesis. The first step in achieving a passive fit is transforming the intraoral relationship of implants through impression procedures.[1]

Many factors affect the accuracy of the implant impression including impression methods, impression materials, impression trays, implant angulation and depth, impression coping modification, and implant connection.[2]

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Two different impression techniques are traditionally used for transferring the impression copings from the implant to the impression: direct (open tray) technique and indirect (closed tray) technique.[3]

The open-tray technique removes the concern for replacing the coping back into its respective space in the impression. Disadvantages of this technique are some movements of the impression coping when securing the implant analog. On the other hand, blind attachment of the implant analog to the impression coping may result in a misfit of components.[1,4,5]

If it is too difficult to access in the posterior region of the mouth, or when the patient has limited interarch space or tendency to gag, the closed tray technique is used. Advantages of this technique are time saving, easier for the operator, and more comfortable for the patient compared to the direct technique. The worst disadvantage of the indirect technique is discrepancy in returning the coping to the original position.[1,4]

Both techniques may be uncomfortable for the patient and the clinician while the impression copings are being screwed and unscrewed intraorally. Slight movement of the copings may result in deformation of the impression material while unscrewing the guide pins from the impression copings during tray removal or replacing the coping-analog assemblies in the impression tray.[6]

The International Team for Implantology (ITI) dental implant system has introduced the snap-on (press fit) impression technique. This technique combines the advantages of both open-tray and closed tray impression techniques. Although it is similar to open-tray technique, there is no need for large tray holes and long guide screws that are difficult to use in mouths with opening restrictions or in posterior areas.[7]

There are a few investigations that compare snap-on and open-tray techniques.[7-11] Two studies reported no differences of impression accuracy between the snap-on and open-tray techniques.[7,9] Two other studies stated that the open-tray technique is more accurate than the snap-on technique.[10,11] Conversely, Cehreli and Akça[8] concluded that the accuracy of snap-on technique is better than that of the open-tray technique.

Since the coping is connected to the implant by pressing instead of screwing in the snap-on impression coping, it is easier to manipulate, time saving, and more comfortable for both the clinician and patient.[6] Furthermore, some issues such as attaching the implant analog to the impression coping or some errors such as distortion of plastic caps may affect the accuracy of this technique.[12] Therefore, further researches are necessary for its accuracy.

Another factor contributing to the misfit is implant angulations. Some studies that used four or more implants reported that the impression of angulated implants is less accurate than that of parallel implants.[1,13-17] Meanwhile, other studies that used two or three implants reported no angulation effect on the accuracy of impressions.[18-20]

Since controversial conclusions have been reported in different studies for the effects of impression techniques and implant angulations on the accuracy of implant impression, the main purpose of the present study is to compare the accuracy of open-tray and snap-on techniques for four implants with different angulations. The first null hypothesis was that there would be no difference between the accuracy of implant impression techniques. The second null hypothesis was that there would be no difference between the accuracy of implant impressions with different angulations.

MATERIALS AND METHODS

In this experimental study, a reference acrylic resin model of the mandible was prepared with bilateral edentulism from the first premolar to the first molar. Using a milling machine (Dentium, South Korea), four holes with diameter of 4.8 mm and depth of 12 mm were drilled. The first hole was perpendicular to the occlusal plane at the right first premolar while the second one was at the left first premolar with lingually inclination of 10°. The third hole was at the right first molar with lingually inclination of 15° and the fourth one was at the left first molar with lingually inclination of 25°. The reference model is shown in Figure 1.

Four tissue-level implants (synOcta ITI solid screw implants, SP 4.1 mm × 12 mm RN) were fixed in the holes using auto-polymerized acrylic resin. A steel cylinder which was accurately machined with the diameter of 5 mm was put at the reference model precisely perpendicular to the horizontal plane; its axis was in z-direction. This cylinder was used as a reference in the measurements. The top plane of the reference cylinder was 3 mm out of the model.

Considering the significance level of 5%, the test power of 80%, the standard deviation of 0.11, and the minimum difference of 0.15 for mean deviations of methods, 10 samples were considered in each group. To make custom trays, after putting two layers of spacer wax on the reference model, 10 open trays and 10 closed trays were made from light-polymerized acrylic resin (Mega-Light Tray, Germany) 24 h before making the impression.

Interior surface of the trays was covered by an adhesive layer of polyvinyl siloxane (PVS) 15 min before making the impression. Afterward, two techniques were employed to make the impression with vinyl polysiloxane (Panasil, Kettenbach, Eschenburg, Germany) using the putty and light body simultaneously. In the first technique (open tray), square impression copings were tightened on the implants using 10 N.cm torque, and ten impressions were made by the open custom tray. The screws of the impression copings were loosened after 10 min, and the impressions were picked up with the impression copings. In the second technique (snap-on), the impression caps were snapped onto the necks of the implants and synOcta plastic positioning cylinders were placed in the impression caps, and ten impressions were made by the closed custom tray. After 10 min, the impression was picked up with the impression cap and the positioning cylinder. Impression copings of the open-tray and snap-on techniques are shown in Figures 2 and 3, respectively.

During polymerization of impression materials, a 2-kg mass was put on the trays at both techniques. After removing the trays, the analogs were connected to the impression copings. The impressions were poured using Type IV dental stone (SH-074, Germany) and mixed according to the manufacturers' recommendation in a vacuum mixer. All casts were separated from the impressions after 60 min and trimmed.

To determine the position of implants, four impression coping screws were tightened on four analogs with a torque of 35 N.cm in each cast. Afterward, the position of each implant was measured by a coordinate-measuring machine (CMM) (Poli, Italy) with 0.001-mm resolution. All casts were positioned on the CMM table using a special fixture to align the mediolateral direction with the *x*-axis and the anteroposterior direction with the *y*-axis. This is shown in Figure 4.

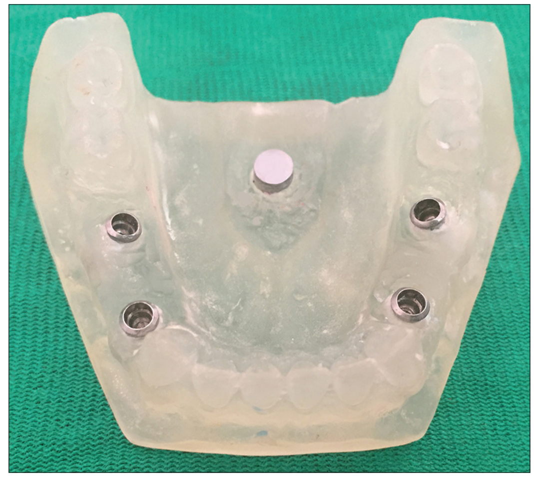

Figure 1: The reference model.

Figure 2: Impression copings of the open-tray technique.

Figure 3: Impression copings of the snap-on technique.

To find a reference point for each cast, the reference cylinder axis was intersected with its top plane. To find the axis of the reference cylinder, CMM probe was touched with six arbitrary points on the cylinder lateral surface. These points were used to produce a virtual cylinder whose axis was the reference cylinder axis. This procedure was also used to determine the axis of each implant in each cast. The reference cylinder axis was considered as *z*-axis of the cast. By measuring the axis of each implant, it was possible to calculate its angle with *z*-axis (θ). For finding the top plane of the reference cylinder, the CMM probe was touched with its three arbitrary points. This plane was considered as the reference *xy* plane for the cast. In each cast, the position of each implant in *xy* plane (*x* and *y*) was determined by intersecting its axis with the reference *xy* plane. The above procedure is shown schematically in Figure 5.

To evaluate the effects of impression technique and implant angulation on the impression accuracy, absolute difference of coordinates of i^{th} implant in *x*- and *y*-axes (x_i and y_i) in each studied cast was calculated with respect to the corresponding implant ones (x_{i0} and y_{i0}) in the reference model (Equations 1 and 2). *i* can change from 1 to 4. This study was also performed by considering absolute difference of direct distance of each implant relative to the reference point (r_i) with respect to the corresponding implant one (r_{i0}) of the reference model in *xy* plane (Equation 3). This distance is actually a resultant value of distances in *x*- and *y*-axes (Equation 4).

$$\Delta x = |x_i - x_{i0}| \quad (1)$$

$$\Delta y = |y_i - y_{i0}| \quad (2)$$

$$\Delta r = |r_i - r_{i0}| \quad (3)$$

$$r_i = \sqrt{x_i^2 + y_i^2}\ ,\quad r_{i0} = \sqrt{x_{i0}^2 + y_{i0}^2} \quad (4)$$

Another criterion for the above study was an absolute difference of each implant angulation (θ_i) with respect to that of the corresponding implant (θ_0) in the reference model [Equation 3].

$$\Delta\theta = |\theta_i - \theta_0| \quad (3)$$

A schematic of x_i, y_i, r_i, and θ_i for the i^{th} implant is shown in Figure 6.

In this study, Δx, Δy, and Δr were used to discuss the linear displacements of implants while $\Delta\theta$ was used as a measure of implant angular displacement with respect to *z*-direction.

Statistical analyses

Evaluation of normality of the data was performed by employing Shapiro–Wilk test. The test results showed that the data were distributed normally.

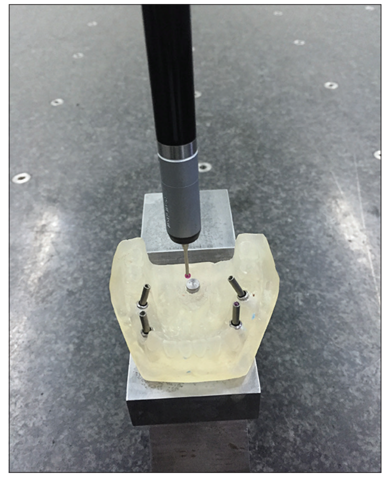

Figure 4: Using a coordinate measuring machine for measuring position and direction of implants.

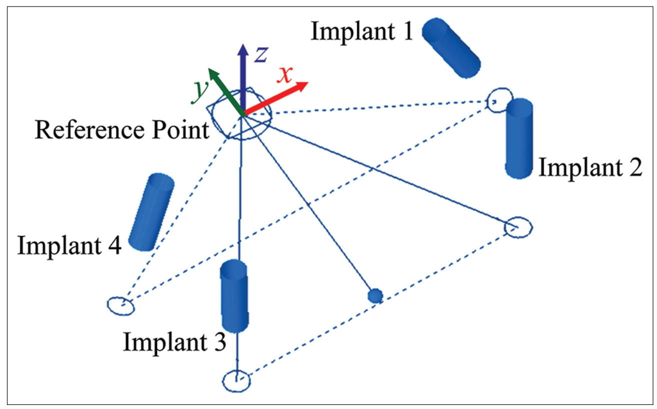

Figure 5: A schematic of determining implant position and axis.

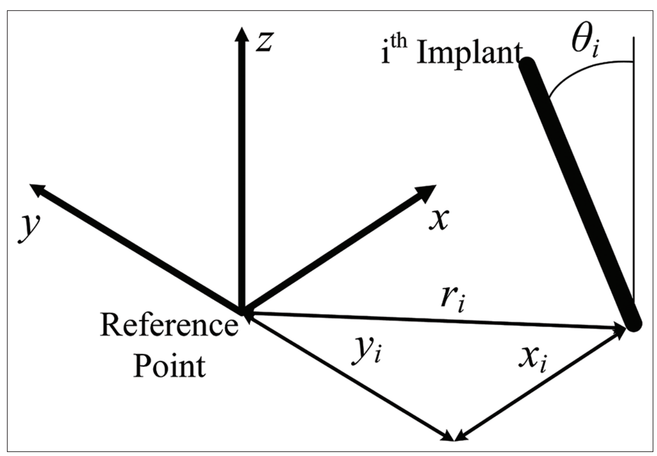

Figure 6: A schematic of x_i, y_i, r_i, and θ_i for the i^{th} implant.

Descriptive statistics were calculated for angular and linear measurements. The effects of impression technique (open tray vs. snap-on) and implant angulation on the impression accuracy were assessed using a two-way analysis of variance (ANOVA) and *post hoc* Tukey's test ($\alpha = 0.05$).

RESULTS

Table 1 gives mean and standard deviation of linear displacements in *x*-, *y*-, and *r*-directions as well as those of angular displacement of four analogs in ten casts with respect to those of the reference model for two studied impression methods.

Results of two-way ANOVA are given in Table 2. It is observed that the accuracy of open-tray impression technique is significantly higher than that of snap-on technique in Δx ($P = 0.002$), Δy ($P = 0.000$), Δr ($P = 0.000$), and $\Delta\theta$ ($P = 0.000$). Further study of Table 2 suggests that implant angulation affects the impression accuracy significantly in Δx ($P = 0.006$), Δy ($P = 0.001$), Δr ($P = 0.000$), and $\Delta\theta$ ($P = 0.000$). Therefore, to find the effect of implant angulation on the accuracy of impression, Tukey's honestly significant difference test was performed and its results are given in Table 3. Although no significant difference is observed for 0°, 10°, and 15° implants in Δx, Δy, and Δr, respectively, 25° implant is significantly less accurate than the others. Moreover, the results of Tukey's test show that 15° and 25° implants are less accurate than 0° and 10° ones in $\Delta\theta$.

Table 2 also shows that the interaction of technique and implant angulation is not significant in Δx ($P = 0.057$), Δy ($P = 0.172$), Δr ($P = 0.16$), and $\Delta\theta$ ($P = 0.477$).

Table 1: Mean and standard deviation of linear (Δx, Δy, and Δr) and angular ($\Delta\theta$) displacements

Technique	Implant number	Δx (mm)	Δy (mm)	Δr (mm)	$\Delta\theta$ (°)
Open tray	1 (25°)	0.14±0.09	0.16±0.09	0.20±0.11	3.11±0.76
	2 (10°)	0.10±0.05	0.07±0.05	0.09±0.04	1.24±0.77
	3 (0°)	0.08±0.05	0.07±0.04	0.04±0.03	0.71±0.44
	4 (15°)	0.14±0.09	0.11±0.06	0.15±0.08	1.74±0.75
	Total	0.12±0.07	0.10±0.07	0.12±0.09	1.70±1.12
Snap-on	1 (25°)	0.47±0.47	0.46±0.35	0.54±0.29	4.48±1.47
	2 (10°)	0.11±0.09	0.22±0.13	0.18±0.10	2.23±0.80
	3 (0°)	0.15±0.12	0.21±0.10	0.13±0.08	1.39±0.68
	4 (15°)	0.31±0.23	0.19±0.17	0.34±0.22	3.26±1.23
	Total	0.26±0.30	0.27±0.23	0.30±0.25	2.84±1.57
Total	1 (25°)	0.31±0.37	0.31±0.29	0.37±0.28	3.79±1.34
	2 (10°)	0.11±0.07	0.14±0.12	0.13±0.08	1.74±0.92
	3 (0°)	0.12±0.10	0.14±0.10	0.09±0.07	1.05±0.66
	4 (15°)	0.22±0.19	0.15±0.13	0.25±0.19	2.50±1.26
	Total	0.19±0.23	0.18±0.19	0.21±0.20	2.27±1.47

Table 2: Results of two-way analysis of variance for linear (Δx, Δy, and Δr) and angular ($\Delta\theta$) displacements

Source	Δx		Δy		Δr		$\Delta\theta$	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Technique	10.299	0.002	21.619	0.000	29.821	0.000	31.121	0.000
Implant	4.489	0.006	5.775	0.001	15.708	0.000	32.955	0.000
Technique × implant	2.622	0.057	1.712	0.172	3.680	0.16	0.839	0.477

DISCUSSION

The first null hypothesis was rejected because the accuracy of open-tray impression technique was significantly different from that of the snap-on technique. Since implant angulations significantly affect the impression accuracy, the second null hypothesis was also rejected. The initial step to a passive fit of implant framework is to transfer implants from the mouth to the master cast precisely with an impression.[21] Any horizontal or vertical error can lead to some kinds of inaccuracy. Horizontal fit discrepancy which results in binding of the screws produces bending stresses in implant system. If a vertical fit discrepancy is present, a preload is used to bring the mating surfaces closer together. In this case, the screw is susceptible to fatigue fractures and loosening.[22]

In this study, comparing the open-tray and snap-on techniques showed that the later has a lower accuracy than the open-tray technique in Δx, Δy, Δr, and $\Delta\theta$.

A few papers have evaluated the snap-on technique; all of them examined parallel implants. Balamurugan and Manimaran[10] reported that the open-tray technique is more accurate than the snap-on technique. Akça and Cehreli[7] and Nakhaei *et al*.[9] reported no significant difference between open-tray and snap-on techniques. This is in contrast with the results of the present study, and they used edentulous mandibular model with parallel implants.

Akça and Cehreli[7] showed that the accuracy of impression of the snap-on technique with stock tray and PVS is similar to that of the open-tray technique with custom tray and polyether. They concluded that the bulk of impression material surrounding the plastic impression cap is thicker in stock tray, and the impression material can easily withstand pull-out forces.

Cehreli and Akça[8] reported that the accuracy of suprastructures fabricated by the open-tray technique was lower than those obtained by the snap-on technique for four implant-supported suprastructures.

Table 3: Tukey's honestly significant difference test results for linear (Δ*x*, Δ*y*, and Δ*r*) and angular (Δθ) displacements

Direction	Implant (I)	Implant (J)	Mean difference (I-J)	*P*	95% CI	
					Lower bound	Upper bound
Δ*x*	1 (25°)	2 (10°)	0.20	0.016*	0.0274	0.3695
		3 (0°)	0.19	0.024*	0.0186	0.3607
		4 (15°)	0.08	0.048*	−0.0886	0.2534
	2 (10°)	3 (0°)	−0.01	0.999	−0.1798	0.1622
		4 (15°)	−0.11	0.290	−0.2871	0.0550
	3 (0°)	4 (15°)	−0.11	0.359	−0.2783	0.0638
Δ*y*	1 (25°)	2 (10°)	0.17	0.007*	0.0366	0.2995
		3 (0°)	0.17	0.005*	0.0422	0.3050
		4 (15°)	0.16	0.011*	0.0286	0.2914
	2 (10°)	3 (0°)	0.01	1.000	−0.1259	0.1370
		4 (15°)	−0.01	0.999	−0.1395	0.1234
	3 (0°)	4 (15°)	−0.01	0.993	−0.1450	0.1178
Δ*r*	1 (25°)	2 (10°)	0.24	0.000*	0.0934	0.3859
		3 (0°)	0.29	0.000*	0.1403	0.4328
		4 (15°)	0.12	0.012*	−0.0219	0.2707
	2 (10°)	3 (0°)	0.05	0.834	−0.0994	0.1932
		4 (15°)	−0.12	0.172	−0.2615	0.0310
	3 (0°)	4 (15°)	−0.16	0.234	−0.3084	−0.0159
Δθ	1 (25°)	2 (10°)	0.24	0.000*	0.0934	0.3859
		3 (0°)	0.29	0.000*	0.1403	0.4328
		4 (15°)	0.12	0.012*	−0.0219	0.2707
	2 (10°)	3 (0°)	0.05	0.834	−0.0994	0.1932
		4 (15°)	−0.12	0.048*	−0.2615	0.0310
	3 (0°)	4 (15°)	−0.16	0.000*	−0.3084	−0.0159

*Indicates that values are significantly different. CI: Confidence interval

In contrast, similar amounts of accuracy were observed for two implant-supported suprastructures produced by both techniques.

Fernandez *et al*.[11] concluded that the open-tray technique with metal impression copings was more accurate than snap-on technique with plastic copings when using the Straumann system. However, there was no difference between open-tray and snap-on techniques for the NobelReplace system.

Machining errors of plastic impression copings may be a reason for lower accuracy of snap-on technique in this study.[23] Other factors that can play a major role in the accuracy of snap-on technique are tactile sensation and the snap mechanism that indicate proper seating of impression coping. In some cases, the dentist feels no snap and improperly assumes that the impression coping is properly seated.[24] Connection of the analog to the plastic coping with snap mechanism may result in movement of coping into the impression material.

In this study, four implants were used with 0°, 10°, 15°, and 25° of angulation. The results showed that 25° implant has less accuracy than 0°, 10°, and 15° implants in Δ*x*, Δ*y*, Δ*r*, and Δθ, respectively. Similar results were also reported by Filho *et al*.[25] and Assunção *et al*.[26] They found that the accuracy of impression with 25° implant is less than parallel implant. Assuncao *et al*.[13] observed a lower accuracy for implants with 25° of angulation in comparison with implants whose angulations were 0°, 10°, and 15°.

In the present study, the accuracy of implant impression with 15° angulation was less than 0° and 10° in Δθ. Therefore, it can be concluded that vertical discrepancy of implant impression is more than horizontal discrepancy.[22]

Sorrentino *et al*.[16] concluded that the implant angulation increases undercuts and may produce strains of impressions due to higher forces required for the impression removal.

Alexander Hazboun *et al*.[27] reported no significant difference in the accuracy of implants with 15° and 30° of angulation. Geramipanah *et al*.[28] reported that the accuracy of 20° and 30° implants is similar. These results are in contrast with the results of the present study.

This study showed no significant difference between the accuracy of impressions with 0°, 10°, and 15° implants in Δ*x*, Δ*y*, and Δ*r*. This is similar to findings of Carr,[4] Conrad *et al*.,[19] and Reddy *et al*.[29] that reported an increase of angulation up to 15° has no effect on the impression accuracy. However, Choi *et al*.[18] reported no angulation effect on the accuracy of impressions with divergence up to 8°. Jo *et al*.[20] concluded that the accuracy of the implant cast is not different for the parallel and 10° angulated implants.

A significant difference was not observed for the interaction of impression technique and angulation in this study. This is in agreement with Conrad *et al*.[19] and Alexander Hazboun *et al*.[27]

As an advantage of this study, a reference model with teeth was used. This increased the generalizability to clinical situations that undercut teeth may affect the accuracy of impression. Furthermore, a sufficient number of implants were examined, and asymmetrical angles of implants were used on two sides of the arch. Another advantage was using an accurate method of three-dimensional measurement (the CMM).

The authors suggest to perform a similar study by preparing the casts at conditions similar to human mouth temperature and moisture as a future research.

CONCLUSION

Within the limitations of this study, it was concluded that:
1. The snap-on technique is less accurate than the open-tray technique in linear and angular displacements
2. In linear (Δ*x*, Δ*y*, and Δ*r*) directions, since the accuracy of 25° angulated implant is significantly lower than that of implants with 0°, 10°, and 15° angulation, up to 15° difference of implant angulation has no effect on implant impression accuracy
3. In angular (Δ*x*, Δ*y*, and Δ*r*) direction, because the accuracy of 15° and 25° angulated implants are significantly less than the accuracy of 0° and 10° angulated implants, an implant angulation difference of up to 10° does not affect the implant impression accuracy.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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