Original Article

Comparison of the 3D Accuracy between Digital and Conventional Impressions in Full Arch Multi-unit Implants at Implant and Abutment Levels: An *in-vitro* Study

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Abstract

The purpose of this study was to compare the accuracy of digital and conventional impression techniques for multiple implants in edentulous areas at different impression levels: the implant and abutment levels. An edentulous mandibular model with five dental implants was fabricated to serve as a reference model (three anterior straight and two posterior angulated implants). Forty impressions were made at the implant and abutment levels using digital and conventional techniques (four cast groups, n = 10 each). Digital impressions were taken with an intraoral scanner. The custom open-tray splinted-impression coping technique was used for the conventional impression. All reference models and working casts were digitized to STL files using a high-resolution laboratory scanner, and the 3D-distances and angulations were measured using PolyWork software for assessing displacement from references. Two-way repeated-measures ANOVA was used to examine the differences between levels of impression and impression techniques and their interactions (α=.05). The Bonferroni post-hoc test and Wilcoxon-sign rank test were used to test differences in accuracy and precision between digital and conventional techniques (α=.05), and the results showed that significant differences were found between the level of impression, impression techniques, and their mutual interaction. For 3D-distance displacement, the implant level-digital impression showed lower trueness values than conventional impression overall (P<0.001). For angulation displacement, there was a significant difference in the conventional-implant level impression group (P=0.003). Overall, no differences were found between the reference model and the two techniques at the abutment level impressions (P=0.508, 1.000). In conclusion, impression techniques and levels of impression affected the transfer accuracy. The abutment level impression with the open-tray conventional technique was more accurate than the digital technique, while the digital technique demonstrated superior outcome in angulation transfer for angulated implants at implant-level impressions. However, the total distance and angulation displacement with both techniques were clinically acceptable.

Keywords: Accuracy, Conventional impression, Dental implant, Digital impression, Impression level

Received Date: Feb 11, 2022 **Revised Date:** Mar 9, 2022 **Accepted Date:** Apr 25, 2022

doi: 10.14456/jdat.2022.48

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Introduction

The passive fit of implant framework restorations is a major factor affecting the longevity of implant-supported restorations.[1,2] Ill-fitting prosthesis frameworks can lead to mechanical and biological complications.[3,4] Impression techniques affect the accuracy of the dental implant position and angulation in the master cast.[5] The conventional open-tray and splinted-coping abutment technique was reported to be the most accurate method for multi-unit implant restorations.[6,7] However, these techniques require more laboratory steps which lead to lengthier production times and potentially more errors. One such error occurs with the use of pour-up stone models due to linear setting expansion and volumetric shrinkage of materials during the nucleation and growth of the crystalline phases of dental stone. The use of type I dental stone while mounting the cast in the articulator also creates some occlusal discrepancy.[8]

Digital impressions can simplify and improve the impression process. The use of digital impressions has gained more popularity due to the production of comparable precise models and reduction of the workflow process.[9,10] Digital impressions with bite registration are created as surface images using an intraoral scanner to position the dental implants. These images are then sent as a standard tessellation language (STL) file to the laboratory. With this workflow, the dentist can omit the use of conventional steps such as making a silicone impression, preparing the stone model, mounting the casts, and shipping the models and articulators to a laboratory.[11,12] Moreover, the current COVID-19 pandemic brings a risk of virus transmission from the dental clinic to the laboratory when using conventional impression techniques.[13,14,15]

For full arch implant-supported restorations, the impression procedure can be performed at the implant or the abutment level, as described by several authors.[16,17] The abutment level impression has been commonly utilized for correcting the angulation of tilted dental implants.[16,17] Multi-unit abutments not only minimize angulation discrepancies, but also eliminate the adaptability component in impression coping, reducing the possibility of impression material deformation during removal.[18,19] Dental implant companies provide both conventional impression copings and scan bodies for abutment level impressions.

Recent studies have compared conventional and digital impressions only at implant levels.[9,10,20-22] This study aimed to investigate the effects of the type and level of the impression technique used on the accuracy of the implant impression and master casts in multi-unit restorations by using three-dimensional (3D) measuring techniques. The null hypothesis was that two different impression techniques and levels of impressions would not affect the transfer accuracy of impressions.

Materials and Methods

<u>The procedure for reference model fabrication</u>

A completely edentulous mandibular model was selected as the reference model (IMP1006-L-SP; Nissin, Kyoto, Japan) (Fig. 1a). Cone-beam computed tomography was utilized to obtain a DICOM file from the model. A surface scan was conducted by a desktop scanner (Ceramill map600; Amann Girrbach AG, Koblach, Austria) to produce STL files from the model. Then, both the DICOM and the STL files were transferred into an implant-planning software program (DTX STUDIO; Nobel Biocare, Zurich, Switzerland) to plan the placement of five dental implants. Bone-level implants (Nobel replace RP, diameter 4.3 mm, length 13 mm) were selected. The median three implants were perpendicular to the occlusal plane and parallel to one another, whereas the two posterior implants (teeth no. 35, 45) were angled 30° distally. The surgical template was then designed and fabricated by a printing machine (NextDent 5100; Amann Girrbach AG, Koblach, Austria) (Fig. 1b).

The five dental implants were placed using a surgical guiding template. After implant placement, three calibrated spherical metal balls (steel balls with diameter 10.0 mm: grade 28 (JIS B 1501, ISO 3290), Sato Tekkou, Osaka,Japan) were fixed to the reference model using self-curing acrylic resin (Unifast III: GC, Tokyo, Japan) to create the reference plane and points for accurate measurement (Fig. 1c).

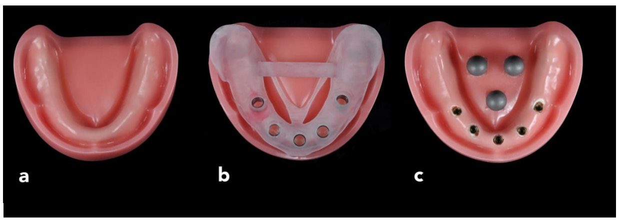

Figure 1 *(a) Completely edentulous mandibular model. (b) Surgical template designed and fabricated for implant placement. (c) Five dental implants were placed and three calibrated spherical metal balls were fixed to the reference model to create the reference plane and points*

Implant level impression

Conventional implant impression

The open-tray splinted-impression coping technique was utilized. The impression copings (Non-engaging transfer impression coping, Nobel Biocare) were attached to the implant fixtures and tightened with 10 Ncm of torque using a torque wrench. Autopolymerizing acrylic resin (GC Pattern resin LS, GC America, Alsip, USA) was used as a splinting material to create resin bars. After 24 hours, the resin bars were sectioned with a diamond disk and re-connected with a minimal amount of the same material to reduce polymerization shrinkage. Then, they were stored for 24 hours (Fig. 2a). Two layers of baseplate wax (Modeling Wax, Sirona Dentsply, Milford, USA) were placed over the splinted-impression coping to create a 2-mm uniform thickness of impression materials. A custom tray was fabricated using autopolymerizing acrylic resin (Formatray, Kerr Corporation, Orange, CA, USA). Five holes were drilled to provide access to the impression copings, and the tray was left to sit for 48 hours. A line was marked on the reference model and on the external surface of the custom tray for positioning the tray while making the impression. Tray adhesive (3M ESPE, Saint Paul, MN, USA) was applied on the intaglio surface of the custom tray and allowed to dry for ten minutes before making the impression. Polyether impression material (Impregum Penta Soft; 3M ESPE, Saint Paul, MN, USA) was used for making the conventional impressions (Fig. 3a). After completely polymerizing for 12 minutes, the individual trays were removed from the reference model. Implant analogs were connected to the impression copings, followed by cast preparation using low expansion (0.08%) type IV dental stone (Kromotypo 4; Lascod, Florence, Italy), which was mixed in a vacuum machine (171971; Wassermann, Hamberg, Germany) for 30 seconds. The working casts were allowed to set for one hour, following the manufacturer's recommendations, before separating them from the impressions. All the working casts were trimmed, finished, and stored at room temperature for one week before the measurements. Ten implant-level conventional impressions were made by the same clinician to obtain ten working casts (Fig. 3b).

Digital impression

To create each digital-implant impression, a digital scan body (Non-engaging, 2B-B Elos Accurate IO Nobel Biocare scan body, Elos Medtech AB, Gothenburg, Sweden) was inserted into the dental implants (Fig. 2c). The same scan body was moved from the correlation position in all casts to eliminate any potential interference associated with scan bodies, and then scanned using the intraoral scanner (Trios3; 3Shape, Copenhagen, Denmark). The digital scan continued sequentially, starting from the occlusal aspect of the scan body at the left molar area, continuing to the scan body at the right molar area, then to the lingual aspect of the scan bodies, and finally to their buccal aspect (Fig. 3c). After the scanning procedure, the STL files of all ten digital impressions were transferred to a software program (PolyWorks; Hexagon, Stockholm, Sweden) for measurement (Fig. 3d).

Abutment-level impression

Multi-unit abutments were selected and prepared. For the median three implants, 0° abutments were prepared for making abutment-level impressions, whereas two angulated 30° multi-unit abutments were used for the two posterior implants (Fig. 2b).

Conventional implant impressions

The open-tray splinted-impression coping technique was used, similar to the one used for the implant-level impression. Ten abutment-level conventional impressions were made to obtain ten working casts.

Digital impression

A digital scan body (Non-engaging, 2C-A Elos Accurate IO Nobel Biocare scan body) was inserted into the dental implants. Then, the same scanning procedure described for the implant-level impression was performed to obtain ten STL files (Fig. 2d).

All scans and impressions were obtained by the first author, who has experience in digital scanning and conventional impression (more than 40 pilot scans).

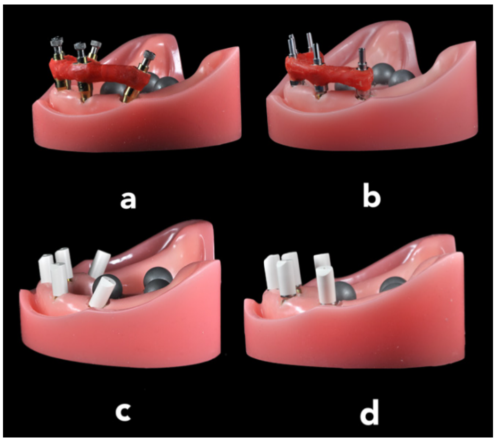

Figure 2 *(a) Splinted angulated impression copings in the conventional technique for an implant level impression. (B) Angulation of impression copings of two posterior implants corrected by using multi-unit abutments during an abutment level impression. (c) A digital scan-body inserted for digital impressions at the implant level. (d) The angulation of digital scan-bodies of two posterior implants corrected by using multi-unit abutments for an abutment level impression*

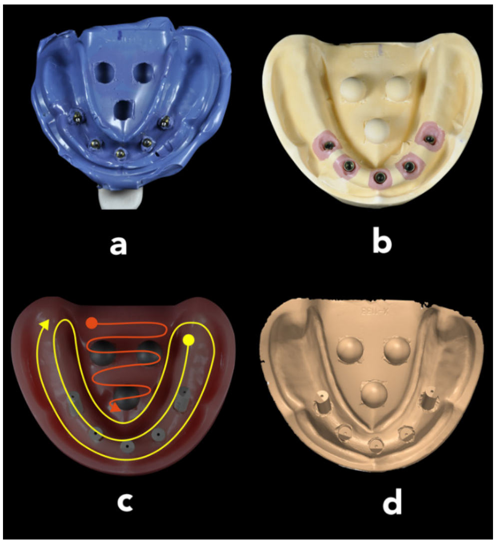

Figure 3 *(a) Polyether impression material was used for the open-tray splinted-impression coping technique. (b) Conventional working cast. (c) Digital impression scanning strategy. (d) Digital impression*

<u>The measurement procedure</u>

A desktop scanner (Ceramill map600; Amann Girrbach AG, Koblach, Austria) with a manufacturer-specified measurement accuracy of 4 μm was used to digitize the reference model and conventional working casts to create STL files. For digital impressions, the surface scan data obtained from the intraoral scanner were used. All data were analyzed using the PolyWorks software program. The software's geometric feature was used to determine the virtual three calibrated spherical balls. Each sphere was measured three times in order to calibrate the constant diameter of sphere balls (10 mm) and to create the center point of the spheres. A horizontal reference plane was created by connecting the center points of the three calibrated spherical balls, no. 1 (C1), no. 2 (C2), and no. 3 (C3). A reference point was set at the center between C1 and C2, and the datum axis was created using the C3 line. Implants were numbered from 1 to 5 from the posterior right to the posterior left (Fig. 4a). A cylindrical digital scan body represented the position and angulation of the dental implants. The central axis of the scan body and the perpendicular horizontal plane of the top of the scan body head were identified by the geometric software. The intersection between the central axis and the top plane of the scan body was calibrated to create a virtual implant position point (Fig. 4b). Then, the distances from each implant position point to the reference point were measured to determine the 3D-distance values (Figs 4a, 4b). The angulation of the central axis of the cylindrical scan body to the horizontal reference plane was measured to determine the angulation values (Fig. 4c).

Statistical analysis

The accuracy assessment formula used to calculate trueness and precision values was based on ADA/ANSI Standard No. 132.[23]

Trueness = $\left|(d_R - d_M)\right|$, :

Reference value – Measured value

Precision = $\left|(d_A - d_M)\right|$, :

Average of the measured value - Measured value

The mean and standard deviations of the trueness and precision values of each sample group were analyzed using descriptive statistics. The Shapiro-Wilk test was used to check for normality, and this test found that certain raw data did not have a normal distribution. As a result, non-parametric statistics were used. Two-way repeated-measures ANOVA was used to test the differences between the level and technique of impression methods and their interactions. The Bonferroni post hoc multiple comparison test was used to examine the differences between digital and conventional impression techniques in comparison to reference models in each level of impression. A Wilcoxon signed-rank test was used to compare the median of precision values between conventional and digital techniques. The level of significance was set at 0.05 (CI: 95%). All statistical analyses were carried out using statistical software (SPSS 16.0, IBM Corp, Armonk, NY, USA).

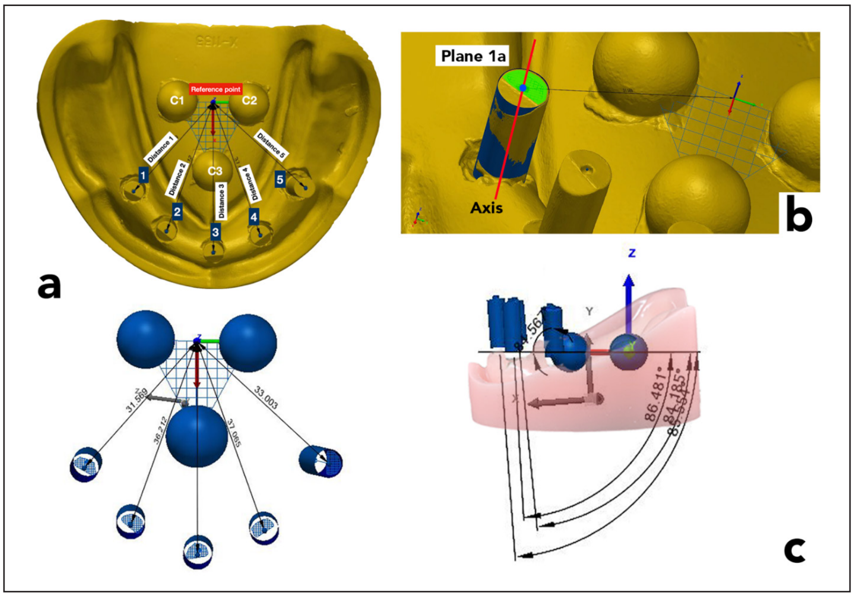

Figure 4 *(a) Measurement method to analyze the 3D-distance of dental implants. A horizontal reference plane was created by connecting the center points of the three calibrated spherical balls C1, C2, and C3. A reference point was set at the center between C1 and C2, and the datum axis was created using the C3 line. The individual implant distance is defined as the distance from the reference point to the scan-body point. (b) The scan-body point was created by the intersection between the horizontal plane of the top of the scan body (Plane 1a) and the long axis of the scan body (red arrow). (c) Angulation of implant was measured by the difference between the angulation of the central axis of the scan body and the horizontal reference plane*

Results

The mean values, standard deviation values, and precision values of the 3D distances and angulation displacement of the conventional and digital impression techniques compared with the reference model are presented in Tables 1 and 2. The Wilcoxon signed-rank test reported that there was no statistically significant difference between the precision values of conventional and digital techniques (*P*=1.000). The two-way repeated-measures ANOVA between the groups determined a statistically significant difference between the level of impression, the impression techniques, and their interaction (Table 3). Multiple comparisons using the Bonferroni post-hoc test shows that a conventional impression resulted in more accurate trueness values in 3D-distances than did the digital technique (Table 4) (*P*=0.257 and *P*=1.000). For angular displacement, both techniques showed significant differences from the reference model in different positions. Overall, the digital technique showed superior accuracy in terms of angulation transfer on the implant level, as there was no significant difference from the reference model (Table 5) (*P*=0.094). At the abutment level impression, there was no significant difference between the conventional and digital techniques compared with the reference model in terms of 3D-distance and angulation displacement (*P*=1.000 and *P*=0.50)

Table 1 *Mean values ± standard deviation (SD) of trueness and precision values of 3D-distances displacement (mm)*

Implant position	n	Implant level				Abutment level			
		Conventional		Digital		Conventional		Digital	
		Trueness	Precision	Trueness	Precision	Trueness	Precision	Trueness	Precision
Overall	40	-0.024 ± 0.091		-0.137 ± 0.228*		0.101 ± 0.250		0.112 ± 0.252	
1 (Tilted)	10	-0.034 ± 0.052	0.002 ± 0.049	-0.046 ± 0.183	0.036 ± 0.017	0.021 ± 0.077	0 ± 0.073	0.027 ± 0.074*	0 ± 0.070
2	10	-0.032 ± 0.044	0.003 ± 0.042	-0.138 ± 0.224	0.061 ± 0.203	-0.022 ± 0.066	0 ± 0.062	-0.087 ± 0.079*	0 ± 0.074
3	10	-0.033 ± 0.072	0.019 ± 0.065	-0.039 ± 0.232*	0.072 ± 0.208	-0.049 ± 0.056*	0 ± 0.052	-0.118 ± 0.055*	0 ± 0.052
4	10	-0.060 ± 0.147	0.012 ± 0.139	-0.097 ± 0.189	0.065 ± 0.168	-0.038 ± 0.071	0 ± 0.067	-0.049 ± 0.062	0 ± 0.058
5 (Tilted)	10	0.047 ± 0.080	0.002 ± 0.076	-0.023 ± 0.196	0.067 ± 0.175	-0.037 ± 0.045	0 ± 0.043	-0.087 ± 0.087*	0 ± 0.082

**P-value <0.05 is significant*

*For trueness values, the Bonferroni post hoc multiple comparison test * showed a statistically significant difference in trueness values from the reference model*

For precision values, the Wilcoxon signed-rank test compared the median of precision values between conventional and digital techniques, and no statistically significant findings were found

Table 2 *Mean values ± standard deviation (SD) of trueness and precision values of Angulation displacement (degree)*

Implant position	n	Implant level				Abutment level			
		Conventional		Digital		Conventional		Digital	
		Trueness	Precision	Trueness	Precision	Trueness	Precision	Trueness	Precision
Overall	40	-0.207 ± 0.421*		0.262 ± 0.836		0.042 ± 0.210		0.111 ± 0.858	
1 (Tilted)	10	0.147 ± 0.315	0.016 ± 0.314	0.140 ± 0.646	0.142 ± 0.628	-0.168 ± 0.258	0 ± 0.243	-0.838 ± 0.672	0 ± 0.634
2	10	-0.104 ± 0.273	0.045 ± 0.268	0.588 ± 0.823	0.231 ± 0.786	0.224 ± 0.141	0 ± 0.133	0.549 ± 0.639	0 ± 0.602
3	10	-0.337 ± 0.127*	0.021 ± 0.118	0.335 ± 0.818	0.183 ± 0.755	-0.072 ± 0.054	0 ± 0.051	0.572 ± 0.659	0 ± 0.621
4	10	-0.229 ± 0.662	0.021 ± 0.627	0.506 ± 0.887	0.176 ± 0.824	0.128 ± 0.174	0 ± 0.164	0.198 ± 0.464	0 ± 0.438
5 (Tilted)	10	-0.508 ± 0.254*	0.006 ± 0.241	-0.356 ± 0.398	0.092 ± 0.367	0.097 ± 0.162	0 ± 0.153	0.475 ± 0.212	0 ± 0.200

**P-value <0.05 is significant*

*For trueness values, the Bonferroni post hoc multiple comparison test * showed a statistically significant difference in trueness values from the reference model*

For precision values, the Wilcoxon signed-rank test was used to compare the median of precision values between conventional and digital techniques, and no statistically significant findings were found

Table 3 Two-way repeated-measures ANOVA, showing result of effect of level, types of impressions, and their interaction on 3D-distance and angulation accuracy

Source	*Sum of squares*		*Df*		*Mean square*		*F*		*P-value*	
	3D-distance	Angulation	3D-distance	Angulation	3D-distance	Angulation	3D-distance	Angulation	3D-distance	Angulation
Level of impression	343.805	3336.134	1	1	343.805	3336.134	61.5	35.592	<.001*	<.001*
Types of impression	0.289	3.807	1.164	1.168	0.249	3.258	8.065	6.204	0.004*	0.0012*
Level x type of impression	0.248	2.036	1.309	1.318	0.189	1.545	11.386	5.111	<.001*	0.019*

**P-value <0.05 is significant*

Table 4 Results of multiple comparisons of ***3D-distance*** displacement on different impression technique on implant- and abutment-level impression

	Implant level (*P*-value)						Abutment level (*P*-value)					
Implant position	1 (tilted)	2	3	4	5 (tilted)	Overall	1 (tilted)	2	3	4	5 (tilted)	Overall
Reference vs conventional	0.206	0.121	0.527	0.689	0.289	0.257	1.000	0.889	0.047*	0.319	0.067	1.000
Reference vs Digital	1.000	0.121	0.004*	0.412	1.000	<0.001*	<0.001*	0.015*	<0.0001*	0.079	0.025*	0.348
Conventional vs Digital	1.000	0.315	0.014*	1.000	1.000	0.006*	0.001*	0.431	0.510	1.000	0.237	1.000

**P-value <0.05 is significant*

Table 5 Results of multiple comparisons of Angulation displacement on different impression technique on implant- and abutment-level impression

	Implant level (*P*-value)						Abutment level (*P*-value)					
Implant position	1 (tilted)	2	3	4	5 (tilted)	Overall	1 (tilted)	2	3	4	5 (tilted)	Overall
Reference vs conventional	0.519	0.764	<0.001*	0.901	<0.001*	0.003*	0.166	0.073	0.156	0.891	0.227	1.000
Reference vs Digital	1.000	0.151	0.109	0.315	1.000	0.094	0.150	0.055	0.052	0.558	0.158	0.508
Conventional vs Digital	1.000	0.043*	0.010*	0.111	0.005*	0.001*	0.006*	0.546	0.028*	1.000	<0.001*	1.000

**P-value <0.05 is significant*

Discussion

Digital impressions are becoming increasingly common due to their comparable accuracy to conventional impressions, as has been reported in many studies. However, few studies have reported the effects of the level of impression to the accuracy of digital impressions compared with conventional impressions in the full edentulous arch. The results of this study indicate that the abutment-level conventional open-tray impression technique has superior accuracy in 3D-distance transfer compared with the digital impression. With angulated implants on the implant level, the digital technique is advantageous. Therefore, the null hypothesis stating that impression techniques and levels of impressions would not affect the transfer accuracy of impressions was rejected.

The level of impression can affect the accuracy of angulation transfer. The results of this study show that the abutment-level impression improves the angulation transfer accuracy of the conventional technique, since it reduces the angulation of the impression coping with an angled multi-unit abutment. Moreover, the abutment-level impression coping connection is different from the implant level, as its external connection without the adaptability concern allows easier removal of the tray. Conversely, without using impression materials and removing impression coping, an angulation of 30° of two posterior implants in this study did not affect the angulation transfer accuracy of the digital impression. The digital impression shows that the values of angulation transfer had no significant difference from the reference model in both implant and abutment level impressions. These findings are consistent with those of an in-vitro study which reported that the accuracy of digital impressions was not affected by implant angulations of up to 30°.[20,21] Abutment-level impressions do not provide a definitive benefit for digital techniques.

According to the impression technique, digital impressions seemed to be inferior to conventional impressions by showing 3D-distance displacement differences that were statistically significant in many implant positions compared with the reference model, both in implant and abutment level impressions. These findings are consistent with those of studies for full arch digital impressions.[22,24] Digital impressions present a typical deviation pattern in the complete arch scan by increasing deformation toward the distal end of the dental arch, which is both the beginning and the end point of the scanning process.[22,25] This deviation is caused by the process of stitching multiple images together to construct a full arch image using a software program. This could be the inevitable limitation of digital impressions unless the software developer can solve this error. Nevertheless, the results of conventional and digital impressions in this study were within clinically acceptable ranges. Jemt *et al.* stated that a misfit of around 150 µm does not statistically correlate with marginal bone-level changes, and that the multi-unit implant prosthesis can function for several years under biologic tolerance in the living bone around dental implants.[3] The conventional technique showed a mean 3D-distance deviation of 32–60 µm with the implant-level impression and 21–49 µm with the abutment-level impression. The digital technique showed a mean 3D-distance deviation of 23–97 µm at the implant level and 27–118 µm at the abutment level. However, a consensus regarding the acceptable angulation deviation has not been reached. An *in-vitro* study by Kim *et al.* used the conventional open-tray impression and intraoral digital scans at the implant level in an edentulous maxillary model with six implant replicas and reported that angular deviation of less than 1° was not considered to be clinically significant.[26] The findings of the present study revealed that the deviation with both impression techniques and levels of impressions were less than 1°. Different methods may be used in the evaluation of full arch impression accuracy. A best-fit algorithm or superimposition technique using software to perform mesh-to-mesh alignment and data analysis was used in many studies.[10,27]

The superimposition process can be designated by the software using an implant scan body or reference teeth as the superimposition point. Then the software superimposes the overall surface of the master model and scans the body into the theoretically ideal position. However, virtual superimposition by the software can create a deviation error by overlapping the physical limitations position.[28] In addition, the superimposition process in completely edentulous areas with a lack of anatomic landmarks or a characteristic geometry feature in the models inevitably creates errors in mesh alignment calculations.[25] Other studies employed the “zero method” by identifying the reference point for true data measurement using the central point of the scan body through the original CAD files and obtained the linear and angular deviations of each implant.[21,26,29] The disadvantages of this technique were the unstable position of the reference body scan and the immeasurable true position of the reference implant.

The methodology of the present study was refined by defining the reference point, plane, and datum axis using three calibration spheres for all the models. This methodology was adapted from a measurement method in the engineering industry called “ball plate measurement.”[30,31] Spheres are basic geometry shapes that are easy to detect with the intraoral scanner and can be precisely analyzed by the CAD software. Additionally, the center point of the spheres was less affected by the deformation of impression materials or by the setting expansion of dental stone, unlike the external surfaces of spheres or another geometry feature.[30,31]

In this study, the laboratory reference scanner was calibrated for this experiment and the accuracy was confirmed to be 4 μm, as specified by the manufacturer. This is within the range of accuracy of reference scanners of other studies.[10,21,27] Furthermore, the present study used a reference model with silicone soft tissue to simulate an actual clinical situation, which contrasts to prior studies that used models only made of hard material.[7,10,20,21,25-27] A scanning strategy is also one of several factors that affect the accuracy of full-arch digital impressions.[32] The edentulous scan strategy from the manufacturer (3shape) was used in this study and considered to be a reliable standard.[33]

A limitation of this study was that it was an *in-vitro* study, in which the digital impression was close to ideal in the scanning process, creating an optimal impression. In clinical situations, the angulation of the scan body, a long-span completely edentulous ridge, movable tissue, tongue movement, and the presence of saliva may make digital impressions difficult and can affect accuracy. Artificial landmarks are required for precise digital impressions in long-span edentulous areas.

The clinical implications of this study show that the abutment level-conventional impression is suitable for complete edentulous arch impression and that digital impressions have the potential to be an alternative to conventional impression procedures for implant-supported multi-unit restorations, as their accuracy is within the clinically acceptable range. In the future, if digital-impression software can eliminate image-stitching errors and increase the efficiency in full-arch impressions, digital impressions will be able to surpass the limits of conventional techniques. Due to the COVID-19 pandemic, dental health professionals (e.g., dentists, hygienists, assistants, and technicians) are more likely to be at risk due to close contact with patients and to exposure to biological fluids, aerosols, and droplet production during dental procedures and laboratory processes. With a fully digital workflow, the risk of infection is reduced, as there is no need to disinfect physical impressions, materials, and instruments., Also, the number of appointments is reduced so there is no need for transportation. Further clinical research comparing digital and conventional impression techniques in clinical conditions are needed to corroborate the findings of this in vitro study.

Conclusion

Based on the results of this study, the transfer accuracy was affected by impression techniques and levels of impression. The abutment-level conventional open-tray impression technique resulted in more accurate trueness values than the digital impression overall. (P=1.000). There was no statistically significant difference regarding precision between conventional and digital techniques. However, the displacement values of both techniques were within clinically acceptable ranges.

Acknowledgements

The authors are grateful to Dr. Wirot Sudatham and the National Institute of Metrology (Thailand) for providing support with places and machines and guidance with the PolyWork software, which is generally used in engineering.

Conflicts of Interest: The authors have no conflicting interests to report with regard to the current study.

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