Dimensional Accuracy of Close Tray vs. Digital Techniques in Implant Impressions – An in vitro study

Yas Mahdavinaderi*
Mahmood Reza Mobayeni*
Homeira Ansari Lari*
Maryam Sayyari*
Mohammad Reza Mousavi*

*Islamic Republic of Iran

Corresponding author: Mahmood Reza Mobayeni
e-mail: Mrmobayeni@yahoo.com

Abstract

Background: Precise dimensional impression accuracy is crucial in dental prosthetics and implantology. This study compares the dimensional accuracy of implant impressions achieved through intraoral scanning and conventional impression methods for parallel and angled implants.
Materials: This study created a partial edentulous maxillary model using heat-cured acrylic, with four fixtures in the premolar areas and two posterior implants inclined 15 degrees lingually on each side. Close tray copings and intraoral scanning with a TRIOS scanner were used for impressions. Distances A1, A2, and A3 (the distance between the most superior point of the central axis of two parallel implants, one parallel, and one angled implant, and two parallel implants, respectively) on the casts were measured using a Coordinate Measuring Machine (CMM). Data were analyzed using Statistical Package for the Social Sciences SPSS, with a significance set at P < .05, and T-tests were conducted.
Results: The digital method demonstrated statistically significant higher accuracy in the A1 and A3 distances (p-value=0.042 and 0.046, respectively). However, no significant difference was observed in the A2 distance (P = 0.205).
Conclusion: Digital methods proved more effective for transferring implant positions and creating related prosthetics, particularly in cases with notable implant angle variations. Nonetheless, both digital and conventional methods are clinically acceptable for implant position transfer.

Keywords: Dental Implants, Dental Prosthesis, Dental Impression Technique, Dental Impression Materials.

Introduction

The dimensional accuracy of impressions in dental prosthetics and implantology is a significant concern in dentistry. Factors such as impression technique and material type contribute to dimensional changes. (1) Achieving an accurate impression with minimal dimensional alterations is crucial for obtaining Passive Fit, a primary goal in constructing prosthetics supported by implants. (2, 3) Failure to achieve Passive Fit can result in biological and mechanical consequences, potentially compromising the success of the treatment (4).
Different techniques are employed for implant impression-taking, each contributing to creating a final cast. (5) Conventional implant impressions use a rigid tray, an impression coping, and elastomeric material to transfer the implant position to the master cast. These impressions can be classified as open-tray or closed-tray techniques. In the open-tray method, copings are unscrewed with the impression, and in the closed-tray method, the transfer stays on the implants while removing the tray from the mouth. (6)
In the digital Impression Technique, the desired area's dimensions, angles, and details are captured by intraoral optical scanners and electronically sent to the laboratory. (7-10)

Authors

Yas Mahdavinaderi - Islamic Republic of Iran

Mahmood Reza Mobayeni - Islamic Republic of Iran

Homeira Ansari Lari - Islamic Republic of Iran

Maryam Sayyari - Islamic Republic of Iran

Mohammad Reza Mousavi - Islamic Republic of Iran

How to Cite
Y. Mahdavinaderi, M. R. Mobayeni, H. A. Lari, M. Sayyari, M. R. Mousavi.
Dimensional Accuracy of Close Tray vs. Digital Techniques in Implant Impressions– An in vitro study
Oral and Implantology
Vol. 16 No. 2 (2024), 62-66.

Digital impressions have transformed prosthodontics, offering superior accuracy and precision over traditional methods. They minimize patient discomfort by eliminating messy materials, accelerate the process, facilitate remote collaboration between dentists and technicians, and enable better patient education and treatment planning through digital model visualization (11).

Although digital scanning systems have demonstrated superior accuracy in some studies compared to conventional impression techniques, (5, 12, 13) limited evidence suggests that traditional impressions may be more accurate for implant-supported restorations in partial edentulism and single implants (14).

Further comprehensive studies with rigorous and consensual methods are needed to examine the accuracy of digital impression methods compared to conventional techniques (15). Therefore, this study compares the dimensional accuracy of impression techniques for parallel and angled implants achieved through intraoral scanning and traditional methods using silicone material with the close tray technique. It is hypothesized that there is no significant difference in dimensional accuracy between digital impression-taking and conventional impression-taking for parallel and angled implants.

Materials and method

Based on previous studies, the minimum sample size for each group was determined to be 12, (12, 14, 16) assuming alpha=0.05, beta=0.2, an effect size of 0.46, and a mean, standard deviation of 0.4 using the advanced repeated measures analysis of variance (ANOVA) power analysis feature in PASS 11.

Model Preparation

A partial edentulous mandibular model with canine-to-canine dentition, similar to the patient's mandible, was formed using transparent heat-cured acrylic (ProBase Hot Acrylic Resin; Ivoclar, Schaan, Liechtenstein) with a 2 mm soft liner (Molloplast; DETAX, Germany) on the ridge surface to mimic clinical conditions.

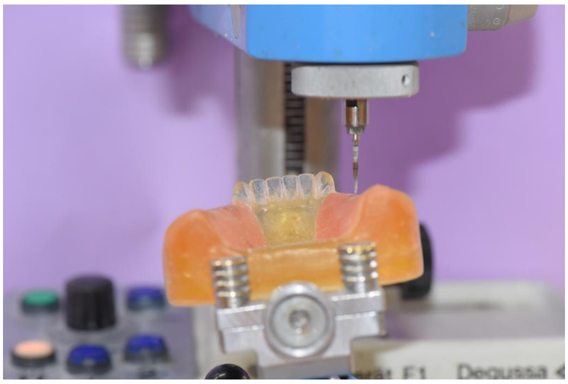

Figure 1. Determining the 15-degree lingual inclination angle of two posterior fixtures.

The model was oriented parallel to the horizontal surface using a milling machine. Two holes were drilled on both sides in the first premolar regions for two titanium screw implant fixtures with a diameter of 3.4 mm and a length of 9.5mm (SIC Invent AG, Basel, Switzerland), placed parallel and perpendicular to the occlusal plane. Implants were inserted into these holes. Next, a 15-degree lingual inclination was determined using a custom jig, and two posterior fixtures (SIC Invent AG, Basel, Switzerland) with the same diameter were placed according to the specified angle in the first molar region on both sides, with a distance of 10 mm from the anterior fixtures. The fixtures were secured using cyanoacrylate adhesive (Razi; Tehran, Iran), and the primary model was prepared. In the next step, close-tray copings (SIC Invent AG, Basel, Switzerland) were placed on the four fixtures (Figure 1).

Conventional Impression Method

In the next step, close-tray copings (SIC Invent AG, Basel, Switzerland) were placed on the four fixtures. To create a specific spacing, two layers of wax (Cavex Set Up Regular; Cavex, Netherlands) were applied in the tooth areas, and one layer of wax was used in the edentulous areas. Two tissue stops were created on the canine teeth, and two crescent-shaped tissue stops were made in the buccal shelf area to establish a custom tray. For the custom tray, VLC material (Hoffmann dental manufaktur; Berlin, Germany) was used. After curing, the tray was perforated using a carbide bur and a handpiece at millimeter intervals, zigzagging in tooth areas and linearly in edentulous areas.

The model was then placed in the holder of a press machine parallel to the horizontal surface. Monophase addition silicone material (Kettenbach GmbH & Co.KG, Eschenburg, Germany) - Monopren was prepared according to the manufacturer's instructions and placed inside the custom tray. After 10 minutes, the tray was gently separated from the model. The silicone material removed the transverse cap, while the copings remained on the fixtures. Then, the guide pins were removed using a hex driver and carefully placed inside the obtained impression. The impression was examined, and if any errors were present, the process was repeated. After 30 minutes, the cast was poured using Type IV gypsum (Fuji Rock, GC America, Chicago, IL, USA), according to the manufacturer's instructions, using a vacuum mixer device (The hardening time was 60 minutes). This process was repeated 12 times. The casts were trimmed and numbered after hardening (Figure 2).

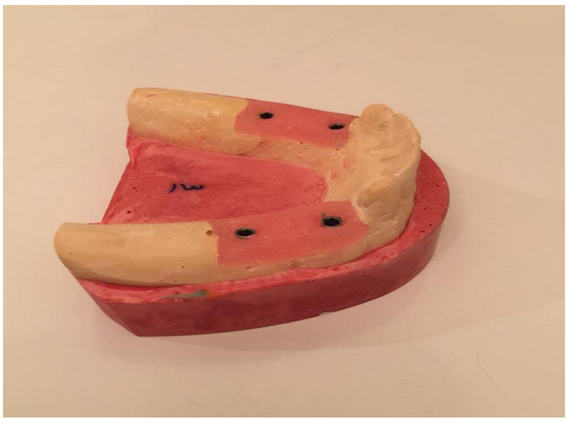

Figure 2. The cast was obtained from molding the original model.

Digital Impression Method

The files were created in the software by defining the implant system and the desired areas. Then, the master model was placed on a white background with ambient lighting, without any interference from external light sources, parallel to the horizontal surface, and all ridge surfaces were scanned with an intraoral scanner, TRIOS.3 (3shape; Denmark), following the manufacturer's instructions by one operator under consistent environmental conditions, including a room with a constant temperature of 22°C, controlled humidity at 45%.

After software validation, the Scan bodies (SIC Invent AG, Basel, Switzerland) were secured onto the fixtures using a Hex driver, and all the surfaces of the Scan bodies were scanned again. In case of any errors, the scan was repeated. This imaging process was repeated 12 times. After scanning with the TRIOS scanner, each model scan was registered as two DCM files in the 3Shape account. These files were then compressed and sent to the printing company as a zip file with the 3OXZ extension. The ASIGA printer (ASIGA; Germany) printed the files using resin (ASIGA, DentaMODEL; Germany). In the process of making the prints, four analogs ((ASIGA, DentaMODEL; Germany) were placed inside the prints, and the prints were numbered (Figure 3, 4).

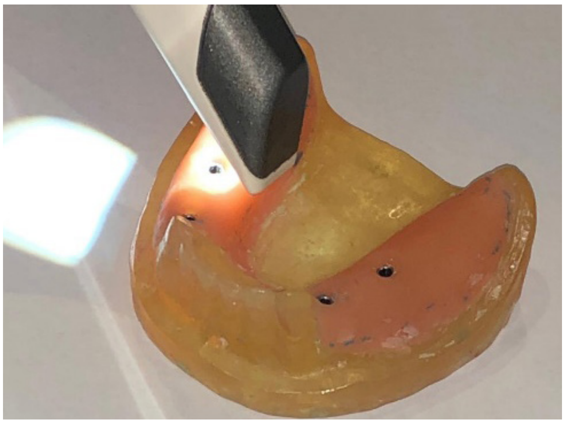

Figure 3. Scanning the original model using the intraoral scanner Trios.

Figure 4. The scanned file, along with the scanned bodies.

After closing the copings on the analogs placed in the casts obtained from impression and prints obtained from scanning, the desired distances were measured in three dimensions (X, Y, Z) using a Coordinate Measuring Machine (CMM) ACE-7-30, Kreon, France) (Figure 5, 6). For precise determination of the central axes, they were aligned with defined surfaces, and the distance between two points of the intersection was calculated in each of the three planes.

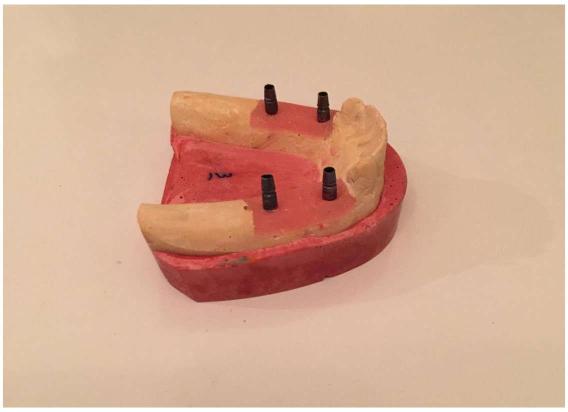

Figure 5. Cast with copings, ready for measurement.

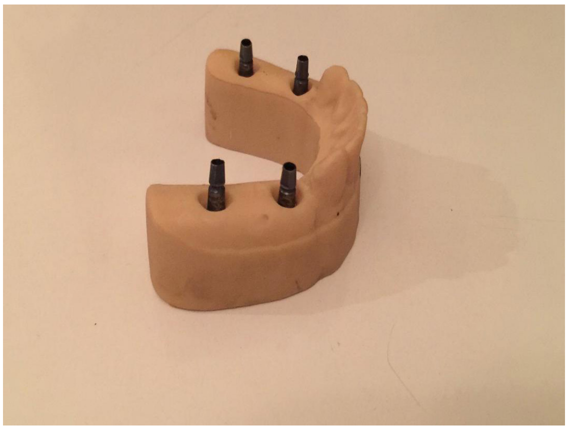

Figure 6. Printed cast with analogs and copings.

The PH10T head and TP20 probe were used, and the measuring unit was µm with an uncertainty of 3 + L/300. The measurable distance limits were defined as follows:

A1: The mean distance between the most superior point of central axes of the anterior and posterior analogs of the right and left side. (one parallel and one angled implant)

A2: Distance between the most superior point of central axes of the left and right anterior analogs. (between parallel implants)

A3: Distance between the most superior point of central axes of the left and right posterior analogs. (between angled implants)

Reports resulting from CMM measurements can be tracked by the International Organization for Standardization (ISO).

Data Analysis

Data analysis was performed using the Statistical Package for Social Sciences (SPSS), incorporating T-test calculations for means, standard deviations, standard errors, absolute errors (ABS.Er), and the determination of minimum and maximum values of differences between the data and the original model at defined distances A1, A2, and A3 for each impression method. The level of significance was 0.05. (P-value=0.05)

Results

Table 1 indicates the mean, standard deviation, and p-value for discrepancies between casts and prints with the original model at three measurement points.

Table 1. The Difference in Accuracy of Implant Positioning at Different Distances, Stratified by Impression Method (in Microns)

Group	Mean Difference	Standard Deviation	P-Value
ABS.Er. * A1			
Conventional	64.333	12.8499	0.042
Digital	48.133	17.6663	
ABS.Er. A2			
Conventional	42.667	16.6857	0.205
Digital	24.45	15.0725	
ABS.Er. A3			
Conventional	103.733	13.5259	0.046
Digital	61.242	18.9454	

*: absolute errors

The dimensional discrepancy in implant position between the conventional and digital groups was statistically significant at distances A1 and A3 with a p- value=0.042 and 0.046, respectively. While it was not significant at A2. (p-value=0.205)

Discussion

The aim of this study was to evaluate and compare the dimensional accuracy of impression techniques for both parallel and angled implants, utilizing intraoral scanning and conventional methods with silicone material employing the close tray technique. Impression-taking accuracy was evaluated by measuring the discrepancies between casts and prints and the original model using a CMM device. The results indicated statistically significant differences in the average size discrepancies between casts and prints with the original model in the distance between the central axes of the most anterior and posterior analogs (A1) and distance between the central axes of the left and right posterior analogs (A3) with digital technique showing lower discrepancy. Therefore, the initial hypothesis was statistically rejected.

The average size discrepancies between casts and prints with the original model were not statistically significant (p-value > 0.05) in the distance between the central axes of the left and right anterior analogs (A2). This indicates that intraoral scanning does not have a specific advantage over conventional impression, as A2 considers the central axis distance of two parallel implants, whereas conventional impression exhibits high accuracy.

Despite intraoral scanning's higher accuracy, the clinically acceptable average discrepancy of less than 60 microns indicates that Close Tray impressions can be used for both parallel and angled implants (angles below 30 degrees). (16, 17)

In a complementary in vivo investigation, Dohiem et al. (6) found that intraoral digital impressions using a scan body demonstrate superior accuracy compared to conventional impressions, aligning with the study's findings. Similarly, Farhan et al. (17) concluded that digital methods, especially intraoral scanning, exhibit superior accuracy in transferring spatial and dimensional implant positions. Marghalani et al. (18) study on a partial edentulous model with two implants align with the findings of this study, showing statistically superior digital impressions but clinically acceptable accuracy for conventional impressions. Alikhasi et al. (12) also reported similar results favoring digital impressions over conventional ones, supporting the study's findings. Other studies corroborate the superiority of digital impressions, particularly with intraoral scanners, over traditional impressions. (5, 19)

In contrast to our findings, Kim et al. (20) investigated complete-arch models with six implants. Their results indicated that conventional open-tray impressions exhibited superior accuracy, showing smaller linear displacements than intraoral digital scans at the implant level. Huang et al. (21) achieved similar findings, confirming that traditional splinted open-tray impressions outperform digital impressions in full-arch implant rehabilitation. Lyu et al. (22) explored the trueness of digital scans for multiple implants using intraoral scanners and conventional impression techniques. Their findings revealed that digital scans had worse trueness values than conventional splinting open-tray techniques, particularly when acquiring cross-arch implant impressions. The contrasting findings can be attributed to the challenges posed by complete-arch scenarios, where superimposition errors and cumulative discrepancies may become more pronounced.

Basaki et al. (14) conducted a study to evaluate the dimensional accuracy and clinical acceptability of restorations made with digital impressions compared to those made with conventional impressions in partially edentulous implant patients. They demonstrated that digital impressions were less accurate and not clinically acceptable in multiple-implant-supported restorations. This finding contrasts with the present study, and the discrepancy may be attributed to the scanners' differences. Basaki used the iTero scanner, while the current study utilized the TRIOS scanner.

Ribeiro et al. (13) also observed superior accuracy of digital impressions in parallel implants but not in angled implants. This discrepancy can be justified by the distinct technology and evaluation methods used in our study and Ribeiro et al.'s investigation. While the current study employed intraoral scanning with the TRIOS scanner and physical measurements using a CMM to focus on dimensional accuracy in implant positions, Ribeiro et al. utilized the 3M™ True Definition Scanner system. They assessed three-dimensional deviations through digital values and reverse-engineering software, emphasizing overall accuracy in models with both parallel and non-parallel implants.

This research contributes valuable insights into the dimensional accuracy of impression techniques for parallel and angled implants. However, this study's limitations include the exclusive use of the TRIOS scanner and specific configurations of the maxillary model, which may restrict generalizability. Simulated clinical conditions may not fully represent real-world complexities. Future studies should explore a wider range of intraoral scanners, consider various clinical scenarios, and conduct longer-term evaluations.

Conclusion

With the limitations of this in vitro study, intraoral scanning demonstrates superior accuracy over conventional methods in transferring implant positions, mainly when dealing with notable variations in implant angles. Although statistically significant differences were observed, both methods demonstrated clinically acceptable accuracy.

References

1. Seyedan, K., et al., Dimensional accuracy of polyether and poly vinyl siloxane materials for different implant impression technique. Res J Appl Sci, 2008. 3(3): p. 257-63.
2. Rismanchian, M. and R. Monirifard, Implant impression, main patterns and modification: review. J Islam Socie Dent, 2008: p. 20-3.
3. Jemt, T. and L. Hjalmarsson, In vitro measurements of precision of fit of implant-supported frameworks. A comparison between "virtual" and "physical" assessments of fit using two different techniques of measurements. Clinical implant dentistry and related research, 2012. 14: p. e175-e182.
4. Choi, J.-H., Y.-J. Lim, and C.-W. Kim, Evaluation of the accuracy of implant-level impression techniques for internal-connection implant prostheses in parallel and divergent models. International Journal of Oral & Maxillofacial Implants, 2007. 22(5).
5. Amin, S., et al., Digital vs. conventional full-arch implant impressions: A comparative study. Clinical oral implants research, 2017. 28(11): p. 1360-1367.
6. Dohiem, M.M., et al., Digital assessment of the accuracy of implant impression techniques in free end saddle partially edentulous patients. A controlled clinical trial. BMC Oral Health, 2022. 22(1): p. 486.
7. Andriessen, F.S., et al., Applicability and accuracy of an intraoral scanner for scanning multiple implants in edentulous mandibles: a pilot study. The Journal of Prosthetic Dentistry, 2014. 111(3): p. 186-194.
8. Joda, T. and U. Brägger, Digital vs. conventional implant prosthetic workflows: a cost/time analysis. Clinical oral implants research, 2015. 26(12): p. 1430-1435.
9. Lin, W.-S., et al., Effect of implant divergence on the accuracy of definitive casts created from traditional and digital implant-level impressions: an in vitro comparative study. International Journal of Oral & Maxillofacial Implants, 2015. 30(1).
10. Ting-shu, S. and S. Jian, Intraoral digital impression technique: a review. Journal of Prosthodontics, 2015. 24(4): p. 313-321.
11. Ahmed, S., et al., Digital Impressions Versus Conventional Impressions in Prosthodontics: A Systematic Review. Cureus, 2024. 16(1).
12. Alikhasi, M., et al., Three-dimensional accuracy of digital impression versus conventional method: effect of implant angulation and connection type. International journal of dentistry, 2018. 2018.
13. Ribeiro, P., et al., Accuracy of implant casts generated with conventional and digital impressions—an in vitro study. International journal of environmental research and public health, 2018. 15(8): p. 1599.
14. Basaki, K., et al., Accuracy of Digital vs Conventional Implant Impression Approach: A Three-Dimensional Comparative In Vitro Analysis. International Journal of Oral & Maxillofacial Implants, 2017. 32(4).
15. Albanchez-Gonzalez, M.I., et al., Accuracy of digital dental implants impression taking with intraoral scanners compared with conventional impression techniques: A systematic review of in vitro studies. International Journal of Environmental Research and Public Health, 2022. 19(4): p. 2026.
16. Papaspyridakos, P., et al., Digital versus conventional implant impressions for edentulous patients: accuracy outcomes. Clinical oral implants research, 2016. 27(4): p. 465-472.
17. Farhan, F.-A. and A.-A. Fatalla, Comparison of the accuracy of intraoral digital impression system and conventional impression techniques for multiple implants in the full-arch edentulous mandible. Journal of Clinical and Experimental Dentistry, 2021. 13(5): p. e487.
18. Marghalani, A., et al., Digital versus conventional implant impressions for partially edentulous arches: An evaluation of accuracy. the Journal of prosthetic dentistry, 2018. 119(4): p. 574-579.
19. Abduo, J. and J.E. Palamara, Accuracy of digital impressions versus conventional impressions for 2 implants: an in vitro study evaluating the effect of implant angulation. International Journal of Implant Dentistry, 2021. 7: p. 1-13.
20. Kim, K.R., K.-y. Seo, and S. Kim, Conventional open-tray impression versus intraoral digital scan for implant-level complete-arch impression. The Journal of prosthetic dentistry, 2019. 122(6): p. 543-549.
21. Huang, R., et al., Improved scanning accuracy with newly designed scan bodies: An in vitro study comparing digital versus conventional impression techniques for complete-arch implant rehabilitation. Clinical Oral Implants Research, 2020. 31(7): p. 625-633.
22. Lyu, M., et al., Accuracy of impressions for multiple implants: A comparative study of digital and conventional techniques. The Journal of Prosthetic Dentistry, 2022. 128(5): p. 1017-1023.