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Comparison of the dimensional accuracy of two polyvinyl siloxane putty-wash techniques and digital impressions for single implants adjacent to tooth crown preparations

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Abstract

Objective: This study compared the dimensional accuracy of two polyvinyl siloxane putty-wash impression techniques with the digital impression method for single implants adjacent to tooth crown preparations.

Methods: Impressions were taken from a dental arch containing a full-metal preparation on the first molar adjacent to a Straumann tissue-level implant at the second premolar site. A laboratory scanner generated a standard tessellation language (STL) file as the reference for comparisons. Three methods were tested, each performed 10 times: (1) one-step putty-wash technique, (2) two-step putty-wash technique, and (3) digital impressions. Dimensional accuracy was assessed by measuring overall die dimensions, die height, die width, and the tooth-implant distance, using Geomagic Wrap software. Statistical analyses included one-way ANOVA and the Kruskal-Wallis test, with significance at $P < 0.05$.

Results: No significant differences were found among the methods for the die height ($P = 0.130$), die width ($P = 0.180$), and tooth-implant distance ($P = 0.486$). However, the digital impression method showed significantly greater overall dimensional accuracy than the one-step putty-wash technique ($P = 0.004$). The two-step putty-wash method showed no significant difference with the one-step method or digital impressions concerning the overall die accuracy ($P > 0.05$).

Conclusions: Digital impressions demonstrated significantly higher overall dimensional accuracy than the one-step putty-wash technique. Die height, die width, and tooth-implant distance were comparable across methods. Digital impressions are recommended for optimal accuracy when taking impressions from single implants adjacent to tooth crown preparations. The two-step putty-wash method offers a reliable alternative when digital tools are unavailable.

Keywords: Dental impression technique, Dental impression material, Vinyl polysiloxane, Dental prosthesis, Dental implants, Dimensional measurement accuracy

Introduction

Dental implants have transformed oral rehabilitation by offering a reliable solution for replacing missing teeth (1). Their long-term success depends not only on achieving initial osseointegration but also on maintaining stability under functional loading (2). A critical factor influencing the success of implant-supported restorations is the passive fit of the prosthetic framework, which directly impacts the biomechanical stability of the implant system (3). Achieving such a precise fit begins with an accurate impression that truly captures the relationship between the implant and its surrounding structures. Any inaccuracies in the impression process can compromise the final restoration, leading to complications such as screw loosening, component fractures, or occlusal inaccuracies (3).

Traditional impression-making techniques, primarily using polyvinyl siloxane (PVS) materials, remain widely used due to their ability to achieve high levels of accuracy (4). These techniques typically employ either a one-step putty-wash or a two-step putty-wash approach (5, 6). It is believed that the two-step technique often yields superior dimensional precision compared to the one-step method (7). Another study highlighted the

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effectiveness of the putty and light-body combination of PVS, particularly in cases where implants are positioned subgingivally (8). However, these traditional methods can be time-consuming, technique-sensitive, and sometimes uncomfortable for patients, limiting their efficiency in clinical practice (9).

Advancements in digital dentistry, particularly the development of intraoral scanners (IOS), have introduced an alternative approach to impression-making. Digital impressions offer several advantages, including enhanced patient comfort, reduced chair time, and digital workflows that facilitate three-dimensional visualization (9). However, questions remain about their ability to achieve superior dimensional accuracy compared to conventional methods, especially in complex clinical scenarios like simultaneous impressions of single implants and adjacent natural teeth (10).

Impression-making for cases involving a dental implant adjacent to a prepared natural tooth presents unique challenges. Traditionally, this process requires multiple sessions: one to capture the prepared tooth and fabricate its crown framework, followed by another to obtain a pick-up impression incorporating the implant coping and crown framework (10). This multi-step process is both time-intensive and prone to errors during framework adaptation (10). An alternative approach involves a simultaneous impression of the implant and adjacent tooth, which saves time and minimizes material waste (11). However, studies evaluating the accuracy of simultaneous tooth-implant impression techniques remain limited, especially when comparing traditional and digital techniques.

The present study aimed to compare three different impression techniques for a dental implant and an adjacent prepared tooth: one-step and two-step putty-wash techniques using PVS, and the digital impression method. The null hypothesis was that there is no significant difference in dimensional accuracy among these methods.

Materials and methods

Study design

This in vitro study was approved by the ethics committee of Mashhad University of Medical Sciences (IR.MUMS.DENTISTRY.REC.1400.090). A mandibular partially edentulous dental arch model (Hoss Ban Mandegar, Tehran, Iran) with a missing right second premolar was used. A standard ITI Straumann tissue-level implant fixture (Institute Straumann AG, CH-4437, Waldenburg, Switzerland) with a diameter of 4.1 mm and a length of 14 mm was placed at the site of the missing second premolar. The adjacent right mandibular first molar underwent full metal preparation (Figure 1). To ensure stability and eliminate movement during impression procedures, the implant was secured with self-curing acrylic resin (Duralay; Reliance Dental Manufacturing, Chicago, IL, USA). Additionally, acrylic side stops were prepared on the model to ensure consistent tray positioning during multiple impressions (see Figure 1).

Reference model generation

The scan body (Institute Straumann AG) was manually screwed into the fixture. The model was scanned using a laboratory scanner (Activity 885, Smart Optics Sensortechnik GmbH, Bochum, Germany) to create a reference model in standard tessellation language (STL) format for later superimposition-based comparisons.

Impression techniques

Three impression techniques were performed ten times each: one-step putty-wash, two-step putty-wash, and digital impressions**.** All the impressions were taken by a single operator.

One-step putty-wash technique

Custom medium-sized, single-winged trays were fabricated with openings on the second premolar site for open-tray implant impressions (Figure 2). The impression coping was screwed onto the fixture, and impressions were taken using A-silicone putty and light-body wash (D-Tak HydroFlow Impression Material;

Figure 1. Mandibular dental arch model used in the study.

Figure 2. Impression captured using the one-step putt-wash method.

SanaPro Dental GmbH, Bremerhaven, Germany). Light-body material was injected around the teeth and coping, while the putty was placed onto the tray. The tray was positioned with light finger pressure. After removal, the impression coping remained embedded in the impression, and fixture analogs were screwed in. Scannable type IV plaster casts (Silky Rock; Whipmix Corp., Louisville, KY, USA) were then prepared. This procedure was performed 10 times, resulting in 10 casts for this impression method**.**

Two-step putty-wash technique

After attaching the impression coping, a 2-mm spacer was created using a vacuum-formed polyethylene sheet (Treedental, Guangdong, China) (Figure 3). The spacer was designed to create a space for the wash material and to protect the putty from any damage caused by undercuts. A putty impression was first made and set aside. The spacer was then removed, and light-body wash was injected to fill the space created by the spacer. The tray, containing the initial putty impression and light-body wash, was repositioned. The impression procedure was performed 10 times, and 10 scannable casts were prepared as described for the one-step method**.**

Digital impression technique

Digital impressions were taken using an intraoral scanner (TRIOS, 3Shape, Copenhagen, Denmark) following the manufacturer's protocol. STL files generated by the digital system were used for analysis. This procedure was repeated ten times, producing 10 STL files.

Accuracy evaluation

For the 20 plaster casts (10 from each putty-wash method), scan bodies (Institute Straumann AG) were manually attached to the fixture analogs, and the cast was then scanned using the laboratory scanner (Activity 885 Smart Optics). The 20 STL files from plaster casts and 10 STL files directly exported from the digital impressions were imported into the Geomagic Wrap 2021 (Artec 3D, Senningerberg, Luxembourg) software**.**

Irrelevant areas, such as below the preparation line, were removed to ensure precise superimposition. The reference model served as the reference dataset, and the test datasets (30 STLs from plaster casts and digital impressions) were aligned using a repeated best-fit algorithm based on the mandibular right second premolar and first molar surfaces.

Accuracy was evaluated using both three-dimensional and two-dimensional approaches. For three-dimensional accuracy, divergences between the reference and test datasets were evaluated along the x-, y-, and z-axes to measure discrepancies in the overall die dimensions.

In the two-dimensional analysis, three specific parameters were measured to evaluate accuracy, as demonstrated in Figures 4 to 6. Die width was determined as the horizontal distance between the

Figure 3. Spacer tray used in the two-step putty-wash impression method.

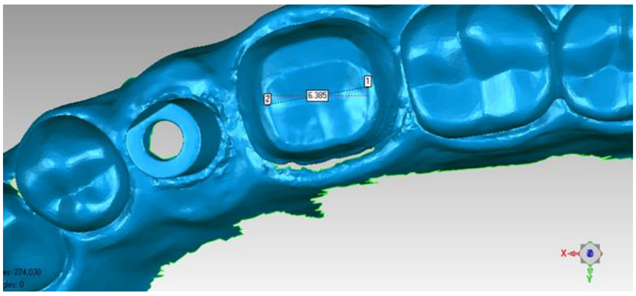

Figure 4. Measurement of die width on the occlusal surface

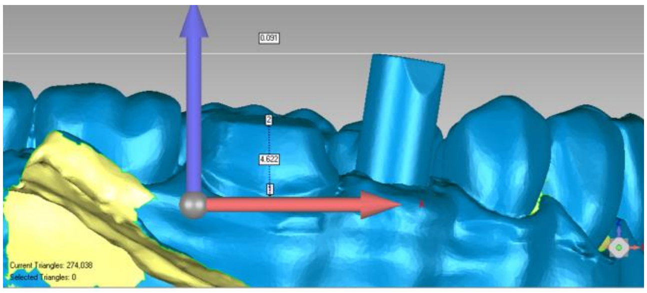

Figure 5. Measurement of die height on the buccal surface

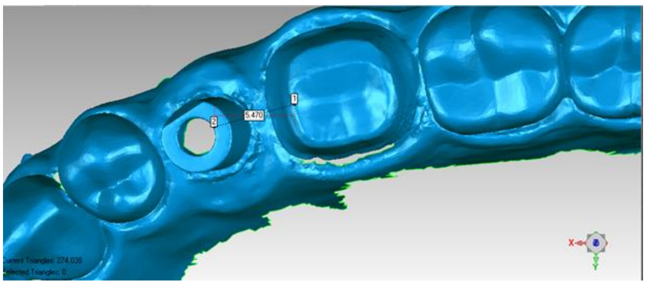

Figure 6. Measurement of implant-tooth distance

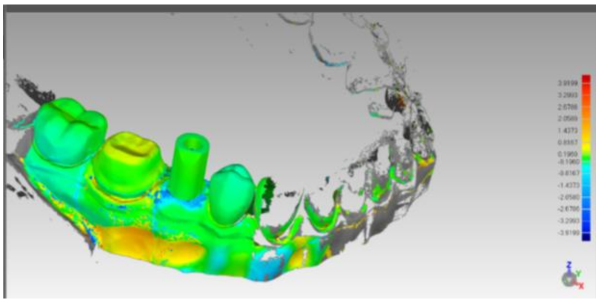

Figure 7. Application of the best-fit algorithm for superimposition and data alignment

most mesial and distal points on the occlusal surface (Figure 4). Die height was measured as the vertical distance from the highest occlusal point to the lowest cervical point on the buccal surface (Figure 5). Additionally, the tooth-implant distance was defined as the distance between the mesial point on the occlusal surface of the die and the internal edge of the scan body (Figure 6).

For all variables, the divergence (inaccuracy) from the reference standard was calculated for ten samples of each impression method, using the best-fit algorithm (Figure 7).

Statistical analysis

The Shapiro-Wilk test was employed to assess the normality of the data. The results showed a normal distribution for the overall die dimensions and die width variables, allowing for analysis with one-way ANOVA followed by Tukey's post hoc test for pairwise comparisons. In contrast, die height and tooth-to-implant distance variables exhibited a non-normal distribution, requiring statistical evaluation by the Kruskal-Wallis test. All statistical analyses were performed using SPSS software (version 22; IBM Corp., Chicago, IL, USA) at the significance level of $P < 0.05$.

Results

Table 1 shows the mean and standard deviation (SD) values for all variables (mm) in the study groups.

One-way ANOVA revealed a statistically significant difference in overall die dimensional accuracy among the groups ($P = 0.004$; Table 1). Pairwise comparisons using Tukey's post hoc test showed that the digital impression technique exhibited significantly higher overall die accuracy compared to the one-step putty-wash method ($P = 0.032$). However, no significant differences were found between the two-step putty-wash technique and either the one-step putty-wash method ($P = 0.114$) or the digital impression technique ($P = 0.174$).

According to one-way ANOVA, there was no significant difference in die width between the study groups ($P = 0.180$; Table 1). The Kruskal-Wallis test also indicated no significant between-group differences regarding the die height ($P = 0.130$) or the tooth-implant distance ($P = 0.486$) (Table 1).

Discussion

Precise detail registration during impression-taking is critical for ensuring restoration fit and longevity (7, 12-15). Among impression techniques, the putty-wash method is widely used and can be performed with either the one-step or two-step approaches. This study compared the dimensional accuracy of the digital impression technique with one-step and two-step polyvinyl siloxane (PVS) putty-wash methods. The results revealed that the impression techniques significantly affected the overall dimensional accuracy of the die, although die height, die width, and tooth-implant distance did not show significant differences.

The digital impression method exhibited significantly greater three-dimensional (overall) accuracy compared to the one-step putty-wash technique. The discrepancy observed between the results of overall dimensional accuracy and other variables is likely due to how overall dimensional accuracy was calculated, as even minor differences in die height and width could compound to produce a significant impact on overall accuracy. Consequently, the null hypothesis, which proposed no

Table 1. Mean ± standard deviation (SD) of deviations from the reference standard (inaccuracy) in the impression techniques (mm) for overall die dimensions, die height, die width, and tooth-implant distance variables

Impression technique	Overall die dimensions	Die height	Die width	Tooth-implant distance
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Digital impression	$0.07±0.03^{a}$	0.11±0.07	0.20±0.13	0.71±1.00
One-step putty-wash	$0.22±0.15^{b}$	0.07±0.07	0.11±0.09	0.15±0.06
Two-step putty-wash	$0.11±0.05^{ab}$	0.07±0.05	0.13±0.11	0.31±0.31
P-value	0.004*	0.130	0.180	0.486

Different superscript letters indicate significant differences between groups as a result of Tukey's post hoc test.

significant differences between the accuracy of techniques, was rejected.

The findings of this study align with some previous studies that highlighted the advantages of digital workflows (16, 17). Lee et al. (16) observed that digital impressions achieved significantly higher accuracy than conventional closed-tray PVS methods. Hafezequran et al. (17) found no significant differences between the one-step and two-step methods, which is in agreement with the present findings.

In contrast to the outcomes of this study, Gedrimiene et al. (18) reported similar accuracy between conventional and digital methods for implant impressions. Dugal et al. (19) reported higher dimensional accuracy with the two-step method than the one-step approach, which contrasts with our observation of comparable accuracy between the two techniques. Nissan et al. (20) concluded that the two-step putty-wash technique was more accurate than the one-step method when assessing the distance between two adjacent teeth. In another study, Nissan et al (21) found that the two-step technique with a 2 mm spacer provided the highest overall dimensional accuracy. The differences between the results of the present study and those of previous authors may stem from variations in study methodologies. For example, Nissan et al. (21) focused on evaluating final restorations, while the present study analyzed die accuracy using superimposition techniques.

Digital intraoral scanners (IOS) are increasingly preferred due to their accuracy, reduced treatment time, and enhanced patient comfort (13). In the present study, the digital impression method also showed the highest three-dimensional accuracy for single implants adjacent to tooth crown preparations, although its difference with the two-step putty-wash technique was not significant. Therefore, the two-step putty-wash method remains a reliable alternative where digital tools are unavailable. This technique’s accuracy, comparable to digital methods, is achieved by creating a stable framework with the preliminary putty impression, minimizing distortions during the final wash step (22). However, the two-step putty-wash method is highly technique-sensitive, requiring careful execution to ensure reliable outcomes.

It is essential to acknowledge the current study’s limitations. The in vitro design, using a simulated dental arch model, does not fully replicate in vivo conditions, such as soft tissue dynamics and patient movement. Additionally, the limited sample size and focus on dimensional accuracy rather than clinical outcomes like the marginal fit or long-term success of restorations restrict the broader applicability of the findings. Future research should incorporate larger sample sizes, in vivo assessments, and evaluations of final restorations to provide a more comprehensive understanding of impression techniques.

Conclusions

The findings of this study highlight the superior overall dimensional accuracy of the digital impression technique with intraoral scanners compared to the one-step putty-wash method. However, no significant differences were observed among the groups for other indices such as die height, die width, and tooth-implant distance. Digital impression methods are recommended for achieving optimal precision. Alternatively, the two-step putty-wash technique can provide reliable outcomes, when digital tools are unavailable.

Acknowledgments

None to report.

Conflict of interest

There is no conflict of interest.

Authors’ contributions

H.R. and H.D. contributed to the study's conception and design. Material preparation and data collection were performed by S.S. A.K. and A.D. Data analysis was conducted by H.R. and A.D. The first draft of the manuscript was written by A.K. and A.D., whereas H.R., H.D., and S.S. critically reviewed and revised it. All authors read and approved the final version of the manuscript.

Ethical approval

Approval was granted by the ethics committee of Mashhad University of Medical Sciences (IR. MUMS. DENTISTRY. REC. 1400.090).

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References

1. Esposito M, Ardebili Y, Worthington HV. Interventions for replacing missing teeth: different

types of dental implants. Cochrane Database Syst Rev 2014(7):Cd003815.
2. Howe MS, Keys W, Richards D. Long-term (10-year) dental implant survival: A systematic review and sensitivity meta-analysis. J Dent 2019;84:9-21.
3. Buzayan MM, Yunus NB. Passive Fit in Screw Retained Multi-unit Implant Prosthesis Understanding and Achieving: A Review of the Literature. J Indian Prosthodont Soc 2014;14(1):16-23.
4. Baig MR. Multi-unit implant impression accuracy: A review of the literature. Quintessence Int 2014;45(1):39-51.
5. Abduo J. Accuracy of casts produced from conventional and digital workflows: A qualitative and quantitative analyses. J Adv Prosthodont 2019;11(2):138-146.
6. Fathi A, Rismanchian M, Yazdekhasti A, Salamati M. Accuracy of tooth-implant impressions: Comparison of five different techniques. Clin Exp Dent Res 2023;9(3):526-534.
7. Yuzbasioglu E, Kurt H, Turunc R, Bilir H. Comparison of digital and conventional impression techniques: evaluation of patients' perception, treatment comfort, effectiveness and clinical outcomes. BMC Oral Health 2014;14(1):1-7.
8. Awad EM, ElSheikh MM, El-Segai AAem. Effect of soft tissue thickness on accuracy of conventional and digital implant impression techniques. BMC Oral Health 2024;24(1):1318.
9. Ahmed S, Hawsah A, Rustom R, Alamri A, Althomairy S, Alenezi M, et al. Digital Impressions Versus Conventional Impressions in Prosthodontics: A Systematic Review. Cureus 2024;16(1):e51537.
10. Fathi A, Rismanchian M, Yazdekhasti A, Salamati M. Accuracy of tooth-implant impressions: Comparison of five different techniques. Clin Exp Dent Res 2023;9(3):526-534.
11. Rehmann P, Wald A, Wostmann B. The reproduction of implants and prepared teeth in one final master cast: a case report. Int J Prosthodont 2013;26(1):51-53.
12. Cicciù M, Fiorillo L, D'Amico C, Gambino D, Amantia EM, Laino L, et al. 3D digital impression systems compared with traditional techniques in dentistry: A recent data systematic review. Materials 2020;13(8):1982.
13. Jedynakiewicz NM, Martin N. CEREC: science, research, and clinical application. Compend Contin Educ Dent 2001;22(6 Suppl):7-13.
14. Ma M, Li X, Zou L, He J, Zhao B. Mechanical properties and marginal fit of prefabricated versus customized dental implant abutments: A comparative study. Clin Implant Dent Relat Res 2022;24(5):720-729.
15. Sanda M, Miyoshi K, Baba K. Trueness and precision of digital implant impressions by intraoral scanners: a literature review. Int J Implant Dent 2021;7:1-25.
16. Lee SJ, Betensky RA, Gianneschi GE, Gallucci GO. Accuracy of digital versus conventional implant impressions. Clin Oral Implants Res 2015;26(6):715-719.
17. Hafezeqoran A, Rahbar M, Koodaryan R, Molaei T. Comparing the dimensional accuracy of casts obtained from two types of silicone impression materials in different impression techniques and frequent times of cast preparation. Int J Dent 2021;2021:1-8.
18. Gedrimiene A, Adaskevicius R, Rutkunas V. Accuracy of digital and conventional dental implant impressions for fixed partial dentures: A comparative clinical study. J Adv Prosthodont 2019;11(5):271-279.
19. Dugal R, Railkar B, Musani S. Comparative evaluation of dimensional accuracy of different polyvinyl siloxane putty-wash impression techniques-in vitro study. J Int Oral Health 2013;5(5):85.
20. Nissan J, Laufer B-Z, Brosh T, Assif D, Maurice T. Accuracy of three polyvinyl siloxane putty-wash impression techniques. J Prosthet Dent 2000;83(2):161-165.
21. Nissan J, Rosner O, Bukhari MA, Ghelfan O, Pilo R. Effect of various putty-wash impression techniques on marginal fit of cast crowns. Int J Periodontics Restorative Dent 2013;33(1):37-42.
22. Radfar S, Alikhasi M, Khorshidi S, Tohidkhah S, Morvaridi Farimani R, Shahabi S. Evaluation of One- and Two-Step Impression Techniques and Vertical Marginal Misfit in Fixed Prothesis. Int J Dent 2023;2023.