Determination of the effect of different implant impression splinting techniques on the dimensional accuracy: an in vitro study

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How to Cite

P. Amini, Z. Rezaeipourmashizi. **Determination of the effect of different implant impression splinting techniques on the dimensional accuracy: an in vitro study.**
Oral and Implantology
Vol. 17 No. 1 (2025), 29-34.
Doi: 10.11138/oi.v17i1.95

Abstract

The current study aimed to determine the effect of different implant impression splinting techniques on dimensional accuracy. Five analog implant pairs were fixed in 5 jaw models using auto polymerizing resin. After completing the polymerization for 1 week, the impression copings were connected to the analogs. Then, the models were scanned by a laboratory scanner, and the results were used as reference data. In the next step, impression copings were splinted with flowable composite material. Then, the copings were separated from the analogs and connected to one of the analogs by turning 180 degrees, and the copings were scanned with a scanner. This process was repeated for auto polymerizing acrylic resin (which was cut in the middle and then connected by the same material), BIS-acryl composite resin, and light cure glass ionomer. The scanner output was entered into the GOM Inspect software, and the obtained information was saved in three-dimensional form and STL format. The distance, depth, and angle of implants were measured by software, and Friedman's non-parametric test was used for statistical analysis in different splinting materials. Data from this study showed that no significant differences were seen regarding implant distances (p=0.121), implant depths (p=0.334), and implant angles (p=0.856) using different splinting materials compared to the master model. In conclusion, we may demonstrate that due to insignificant differences regarding linear, depth, and angular errors between implants and master model as well as acceptable values of the errors, studied splinting materials are recommended to achieve accurate impressions in implant treatments.

Keywords: Implant impression, copings, splint materials, in-vitro study, and dimensional accuracy.

Introduction

The most crucial step in making precise implant prostheses is transferring the three-dimensional intraoral position of the implants to the final casts (1). This purpose has used some techniques, including open and closed impression techniques (2,4). Choosing a specific technique for impression depends on the clinical conditions and the patient's choice (4). To achieve a passive fit in the implant-supported prosthesis, it is essential to accurately transfer the positions and distances of the implants through the impression process. Factors affecting impression accuracy include the type of impression materials, impression techniques, implant number, and angle (5,6). Several impression methods have been proposed to prepare an accurate cast and transfer the position of the implants from the mouth to the cast; there are two main impression techniques: open and closed impression techniques (7,8). In the open tray method, the splint technique is used to increase the accuracy of impression, during which the implants are splinted to each other inside the mouth by self-cure acrylic resin or composite resin. The rigid connection of the copings in this method causes better stability in the impression material. It prevents their movement while tightening the fixture analog or unscrewing and tightening the screws. Some researchers have reported more impression accuracy in the open-tray method than the closed-tray method (9,10,11). Of course, problems in the open-tray method still exist, such as rotational or vertical movements of the copings (11,12). When using acrylic resin for splinting the copings, cutting the acrylic resin and reconnecting it with the resin in the cut area improve impression accuracy due to reduced polymerization shrinkage (14). It is suggested that to increase the accuracy, the impression copings should be splinted to each other (15). The material used to splint the implants in the open-tray technique still effectively fits the superstructure and abutment (16). Recently, using composite resin as a splint material has increased, and therefore, in the present study, this material was also used as a splint material, and its results were reported that its impact on impression accuracy was similar to other materials. Therefore, using composite resin material as a splint material is promising. Using composite resin material eliminates the tedious process of mixing monomer and powder, which is necessary in conventional techniques, during which powder and liquid are mixed and applied using the brush and bead technique. In addition to high accuracy, the use of composite is more liked by the patient and the clinician (17). Practical factors on impression accuracy include the type of impression material, impression technique, material used for splinting the impression copings, and value of fit tolerance in intraoral abutments. Some materials such as acrylic resin, composite resin, dental floss, and stainless steel bars have been used to splint impression copings (10). However, a definite opinion about the superiority of these materials over each other in terms of dimensional stability and impression accuracy has not been obtained. In this regard, the present research was conducted to compare the effect of different splinting techniques in implant impressions on dimensional accuracy.

Materials and methods

The present research used the experimental-laboratory method on implant analogs and different splint materials. The community investigated in the study included impression copings that were splinted to each other using various materials, and their dimensional accuracy in terms of the distance, depth, and angle of the implants compared to the original model was measured and reported in the software. Considering the number of samples in previous research, 10 implant analogs were investigated in this research. Non-probability Sampling was done. In this in vitro and experimental trial, 5 analog implant pairs were fixed in 5 jaw models

Figure 1. Five study models without splints

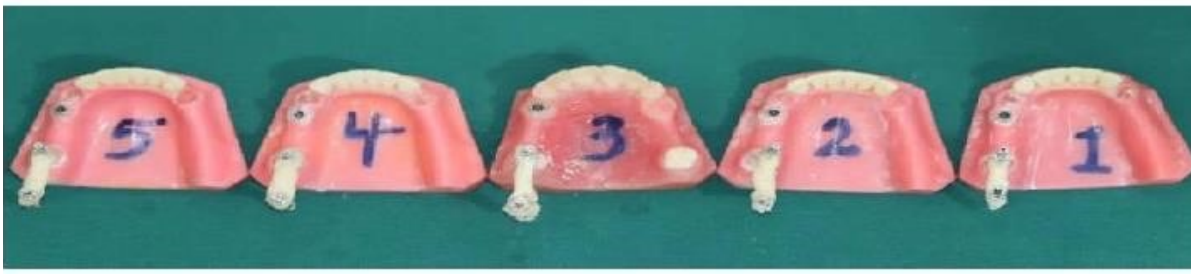

Figure 2. Five study models that were splinted with BIS-acryl composite and 180 degrees rotated

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using auto polymerizing resin. After completing the polymerization for 1 week, the impression copings were connected to the analogs. Then, the models were scanned by a laboratory scanner, and the results were used as reference data. In the next step, impression copings were splinted with flowable composite material. Then, the set of copings was separated from the analogs and connected to one of the analogs by turning 180 degrees, and the copings were scanned with a scanner. This process was repeated for auto polymerizing acrylic resin (which was cut in the middle and then connected by the same material), BIS-acryl composite resin, and light cure glass ionomer. The obtained information was saved in three-dimensional form and STL format. The scanner output was entered into the GOM Inspect software (GOM GmbH, Germany), and the implants' distance, depth, and angle were measured, and the results were recorded.

This research used SPSS (statistical package for social sciences) version 0.25 (latest edition) for data analysis. First, the mean and standard deviation and the minimum and maximum values of the distance, depth, and angle of the implants compared to the original model were calculated in the groups using different splint materials, and the Kolmogorov-Smirnov test was used to determine whether or not the data conformed to the normal distribution. Due to the nonobservance of the data from the normal distribution and the non-establishment of the conditions of the parametric tests, the non-parametric Friedman test. For statistical analysis, the implant's distance, depth, and angle values were compared with the master model in different groups. The rate of the first type of error in the research equals 0.05.

Results

Due to the lack of presuppositions of parametric analysis models, Friedman's non-parametric test was used to statistically analyze the distance error values of the implants compared to the original model and according to the results of this test, no significant differences were seen between different splint materials in this regard (p=0.121; Test score = 7.31). Table (1) presents the average, standard deviation, median, minimum, maximum, and IQR values of the distance of the implants compared to the original model in the application of different splint materials. Therefore, the average distance of the implants in

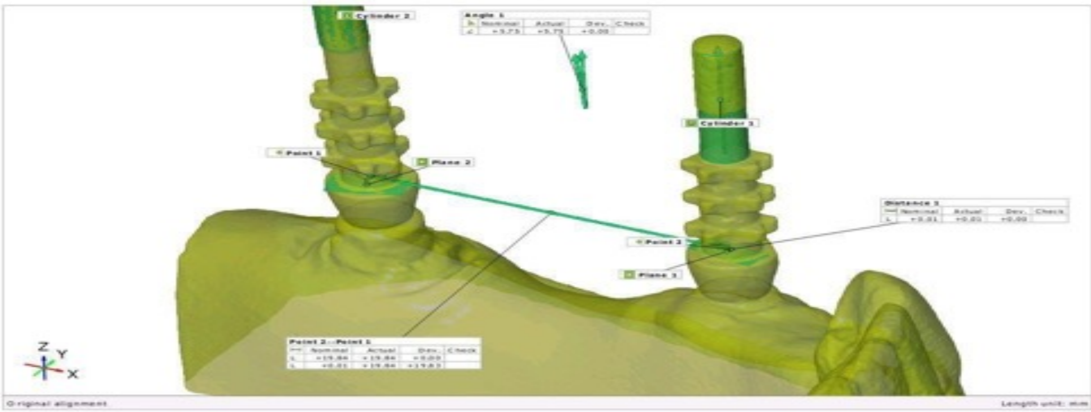

Figure 3. The distance, depth, and angle of two impression copings without splint

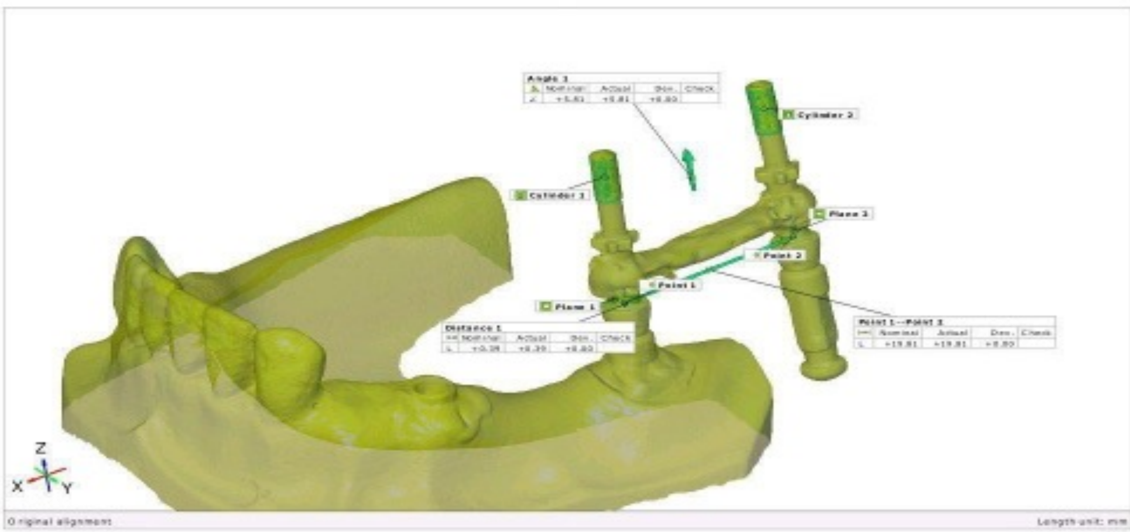

Figure 4. The distance, depth, and angle of two splinted impression copings with light cure glass ionomer

Table 1. Average, standard deviation, median, minimum, maximum, and IQR indicators of the distance values of the implants compared to the original model in the application of different splint materials

Splint material	Average	SD	At least	The middle	Max	IQR
Bis-Aryl Composite	19.94	0.60	18.50	19.80	22.15	2.14
Autopolymerizing Crylic Resin	20.12	0.55	19.14	19.82	21.71	1.97
Flowable Composite	20.03	0.57	18.96	19.85	22.21	1.98
The O riginalModel	20.04	0.61	18.79	19.83	22.34	2.13
Light Cure Glass ionomer	19.97	0.58	18.81	18.81	22.15	2.02

the application of bis-acrylic composite splint, auto polymerizing acrylic resin, flowable composite, light cure glass ionomer, and the original model was equal to 19.944, 20.123, 20.036, 19.970, and 20.040 microns, respectively.

Due to the lack of presuppositions of parametric analysis models, Friedman's non-parametric test was used for statistical analysis of implant depth error values compared to the original cast, and according to the results of this test, no significant differences were seen between the splint materials in this regard (p=0.334; statistic test = 4.57). Table (2) presents the average, standard deviation, median, minimum, maximum, and IQR values of the depth of the implants compared to the original model in the application of different splint materials. Therefore, the average depth of implants in the application of bis-acryl composite, auto polymerizing acrylic resin, flowable composite, primary model, and light cure glass ionomer materials was 2.670, 2.556, 2.292, 2.514, and 2.884 microns, respectively.

Also, due to the lack of presuppositions of parametric analysis models, Friedman's non-parametric test was used for the statistical analysis of the angle error values of the implants, and according to the results of this test, no significant differences were seen between the splint materials in this regard (p=0.856; test statistic = 33 /1). Table (3) presents the mean, standard error, median, minimum, maximum, and IQR values of the implants' angle compared to the primary model when applying splint materials. Therefore, the average angle of the implants when applying acrylic base composite materials, auto-polymerizing acrylic, flowable composite, primary model, and glass ionomer light cure was 3.80, 3.972, 3.998, 3.762, and 3.758 microns, respectively.

Table 2. Average, standard deviation, median, minimum, maximum, and IQR indicators of the depth values of the implants compared to the original model in the application of different splint materials.

Splint material	Average	SD	At least	The middle	Max	IQR
Bis-Aryl Composite	2.67	0.746	0.26	3.04	4.58	3.03
Autopolymerizing Crylic Resin	2.55	0.725	0.01	0.003	4.02	2.87
Flowable Composite	2.29	0.874	0.15	1.92	5.25	3.47
The O riginalModel	2.51	0.765	0.01	2.71	4.11	3.19
Light Cure Glass ionomer	2.88	0.833	0.36	2.92	5.03	3.53

Table 3. Average, standard deviation, median, minimum, maximum, and IQR indicators of the angle values of the implants compared to the original model in the application of different splint materials.

Splint material	Average	SD	At least	The middle	Max	IQR
Bis-Aryl Composite	3.80	1.08	0.68	3.90	6.13	4.70
Autopolymerizing Crylic Resin	3.97	0.85	4.69	3.69	5.55	3.35
Flowable Composite	3.99	0.84	4.76	4.76	5.68	3.61
The O riginalModel	3.76	0.79	3.61	3.61	5.75	3.40
Light Cure Glass ionomer	3.75	0.86	3.69	3.69	5.81	3.88

Discussion

Accurate impression is the essential step in preparing implant prostheses with passive adaptation. The replica should be correct so that the original cast can recreate the clinical conditions of the mouth. Splinting impression copings is done to fix the copings and prevent their movement. Various materials for splint purposes in implant treatments include acrylic resin and its different types (such as self-polymerizing types, dual polymerization and photopolymerization resins), prefabricated acrylic resins, stainless steel bars, orthodontic wires, plastic impression materials, polyvinyl siloxane and polyether, teeth thread, composite resins and resin cements have been used. The splint technique is one of the most common impression techniques in research histories, although there are still some problems and different views. The fundamental problem of this technique is the possibility of failure of the connection between the splint material and impression copings due to the contraction of the splint material (17). In this method, there are also considerations about working time, patient comfort, and accuracy of impression materials and impression copings. Splint materials should be selected according to their characteristics to resist dimensional changes. This resistance creates stability in the copings against rotation when tightening the fixture or analog abutment and also controls the relationship between the implants in a splinted pattern. The choice of impression material is based on factors such as the accuracy of the material, the amount of intraoral undercuts, the time before pouring the mold, and the experience of the clinician (18).

On the other hand, the accuracy of impression technique with splint depends, in most cases, on the resistance to shape changes when the impression material applies force. In the conditions of using hard splint materials, it is possible to prepare accurate master casts. Also, the dimensional stability and hardness of the final prosthesis are related to the type of material used to pour the cast and the strength of the master cast. The advantages of using intraoral scanners for impression, in addition to sufficient accuracy, include reducing patient discomfort, saving time, and simplifying clinical processes for dentists and laboratory technicians (19). Intraoral scanners have reduced the risk of cross-infection by eliminating plastic models and facilitating communication with the dental technician (20).

In the study of Dodia et al. (2022), different materials such as light-cured acrylic resin, prefabricated pattern resin, flowable composite, and bite registration materials were used to determine the impression accuracy. According to the results, the light-cured acrylic resin showed minimal changes compared to the model. It was the main one in terms of three-dimensional distances, and after that, the bite registration material and nanocomposite resin were in the following ranks (7). In the research of Ibrahim and Ghuneim (2013), splint materials, including composite resin and acrylic resin, were used. No significant differences were seen in impression accuracy between them, and these findings are consistent with the current research results (21). Jayaswal (2021) also investigated the dimensional accuracy of multiple implants when using the open-tray impression technique using self-curing acrylic resin, pattern resin and flowable composite materials and showed that the splint with the latter materials caused minimal changes in the position of multiple implants and These changes were all within the acceptable range in terms of clinical conditions. These observations were also evident in the present research (8). However, in some studies, contrary to the present research results, the type of splint material has been affected in impression accuracy. Vigolo et al. (2004) stated that splinting impression copings with Duralay splint material effectively reduced dimensional changes. In a recent research, the profile projector method was used to evaluate samples (22). Also, in 2019, Kavedia et al. showed that splinting impression copings have no benefit in parallel implants. Still, when the implants are not parallel, splinting impression copings increase the accuracy of casts. In a recent study, small gaps between the prosthesis and the implant analog in parallel and non-parallel implants were reduced when using self-polymerizing acrylic resins to splint impression copings (23). The limitations of the current research include its in-vitro condition and performing related processes at room temperature. The behavior of dental materials is somewhat different at the temperature inside the oral cavity. Therefore, dental materials may have differences when used inside the oral cavity. Thus, the results of the present research need to be validated and verified in intraoral conditions.

Conclusion:

In conclusion, no significant differences were observed in terms of implant distance, implant depth, and implant angle when using different splint materials compared to the master model. Therefore, considering the lack of significant differences in the amount of distance, depth, and angle difference between the implants compared to the master model, as well as the acceptable values of the errors, it is possible to use the splint materials investigated in the research to achieve accurate molds in implant impression.

Acknowledgment

The authors thank the Kerman University of Medical Sciences, Kerman, Iran, for their support, cooperation, and assistance throughout the study.

Ethical Approval

This study was conducted after obtaining an ethics code from the Kerman University of Medical Sciences.

Author contributions

All authors reviewed and approved the final version of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the author (s).

Data availability statement

All data presented in this study will be available free of charge to any researcher who reasonably requests them from the corresponding author.

Funding

The author (s) reported no funding associated with the current study.

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