Original Article

Dimensional Accuracy of Three Impression Materials Using One-step and Two-step Impression Techniques: An In-vitro Study

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Abstract

Introduction: An accurate impression is essential to create a well-fitted dental prosthesis. This study aimed to compare the dimensional accuracy of three elastomeric materials using one-step and two-step impression techniques. **Methods:** In this study, 20 impressions were fabricated for each Vinyl siloxane ether (Identium), condensation silicone (Speedex), and additional silicone (Panasil) impression materials by the one-step and two-step impression techniques using perforated metal trays. The one-step impression technique was simultaneously performed with heavy body/light-body materials. In the two-step impression technique, acrylic copings with 2-mm thickness were placed on the abutments to obtain similar spacing for the light-body material. The dimensional accuracy of different impression materials and techniques were measured using distance differences of the stone dies from the master cast; subsequently, the results were compared with the reference model. Data were analyzed using a one-way analysis of variance and Dunnett's tests (α=0.05). **Results:** All impression materials demonstrated an acceptable clinical accuracy. Identium (Vinyl siloxane ether) displayed the most accuracy in both the one-step and two-step impression techniques ($P>0.05$). The best accuracy for Panasil (additional silicone) was found to be the two-step impression technique ($P>0.05$), and the best accuracy for Speedex (condensation silicone) was reported as the one-step impression technique ($P>0.05$). Furthermore, the one-step impression technique was highly accurate in diameter dimension, as compared to the two-step impression technique. **Conclusion:** As evidenced by the results, the accuracy of impression is affected by the impression materials. Moreover, Identium (Vinyl siloxane ether) demonstrated the most accuracy in both one-step and two-step impression techniques.

Keywords: Dental impression materials, Dental impression technique, Silicone, Dimensional accuracy

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Introduction

An accurate impression is essential to create a well-fitted dental prosthesis (1, 2). Nonetheless, one or more observable errors have been detected in 89% of impressions (3). Marked improvements have been achieved in 3-dimensional imaging, computer-aided design, and computer-aided manufacturing (CAD/CAM) systems. However, conventional impression techniques still play a major role in clinical applications and are widely used in many practices (4). A study has indicated that the digital impression is less accurate and has a different pattern of deviation, as compared to the conventional impression (2). The quality of impressions can be affected by several factors, including clinical parameters, impression materials, and impression techniques (5). A variety of materials are currently used in dental impressions. The dimensional accuracy of these materials depends on several factors, such as chemical formulation, setting reactions, time, releasing by-products, and hydrophilicity during disinfecting and casting (4, 6-8). Synthetic elastomeric impression materials, including polysulfide, addition silicone, condensation silicone, and polyether, have recently come into vogue. This popularity is due to their excellent elastic recovery, adequate tear resistance, optimal accuracy, and virtually ideal dimensional stability (1). Vinyl siloxane ether has been recently introduced with good mechanical and flow properties, excellent wetting characteristics in the unset, and set conditions; however, its accuracy has not been well-established yet (4). In general, impression techniques can be categorized into mono-phase and dual-phase. Materials used in the mono-phase technique have a medium viscosity, and the impression technique is completed in a single-step procedure. In the dual-phase technique, the heavy-body/light-body technique is used in the one or two steps with or without spacer (1, 8). Some studies have noted that the dimensional accuracy of impression depends more on technique rather than impression material. Nevertheless, impression materials were found to have the most important part of the impression dimensional accuracy according to some other studies (9-11). In addition, no significant difference was detected between the one-step and two-step impression techniques in some other investigations (12, 13). Nonetheless, the results of one study were indicative of more accuracy in the two-step impression technique, in comparison to the one-step impression technique (1). There exists considerable controversy over the effects of the impression technique and material on the accuracy of stone dies. With this background in mind, this in vitro study aimed to compare the dimensional accuracy of three elastomeric materials, including Vinyl siloxane ether, condensation silicone, and additional silicone using one-step and two-step impression techniques.

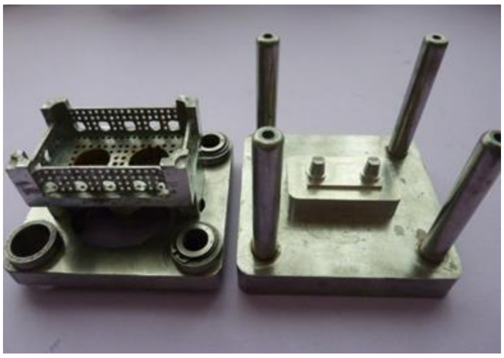

Figure1. The stainless steel model and special tray

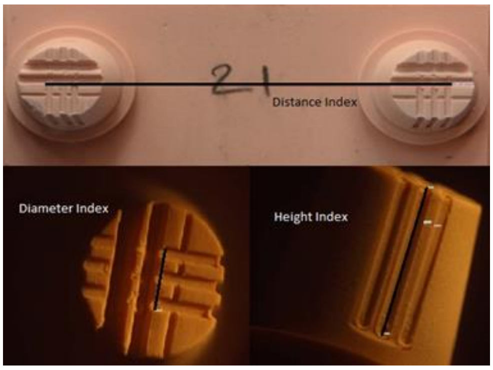

Figure 2. Measurement of intra-abutment and inter-abutment distances

Materials and Methods

This in vitro study was carried out in the Department of Prosthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran. A stainless steel model containing 2 tapered abutments was designed with 3D Auto CAD and made by Computerized Numerically Controlled (CNC) according to the ANSI/ADA specifications (8.015 mm height, 6.330 mm and 8.450 mm base dimensions, and 28.270 mm distance between the centers of the abutments). Reference grooves were prepared on occlusal and proximal surfaces. Horizontal grooves with 0.250 mm, 0.500 mm, and 0.750 mm and vertical grooves with 0.250 mm dimensions were made on the occlusal surface (9). Vertical grooves were extended to the axial surfaces. To make a reproducible impression position, the stainless steel model was established on a model with 2 plates (with a 100 mm width and 110 mm length) and 4 guiding rods. Perforated metal tray and the stainless steel model were attached to the upper and lower plate, respectively. The distance between abutments and the tray was measured at 5 mm in the base of the abutments and 6 mm in occlusal and proximal walls (Figure 1). A total of 60 impression samples were assigned to three groups. Thereafter, 20 impression samples were made for each material, including Identium Vinyl siloxane ether (A-Silicone+Polyether, Kettenbach, Germany) as group I, Panasil additional silicone (A-silicone, Kettenbach, Germany) as group II, and Speedex condensation silicone (C-silicone, Coltene, Switzerland) as group III. In each material group, 10 impressions with the one-step technique (Method A) and 10 impressions with the two-step technique (Method B) were made. In the one-step impression technique, heavy body/ light body impression materials were simultaneously used. In the two-step impression technique, the heavy body/light body material was made first with a 2 mm-thick coping that is fitted onto the abutments. Subsequently, in the second step, the copings were removed from the abutments and the light body material was added. All impression materials were used by one person according to the manufacturers' instructions. The pressure of placing the tray on the stainless steel model was raised until the establishment of absolute contact between the tray and the model interface. To simulate the intraoral environments, the tray and abutment complexes were kept in the humidified incubator at 37˚C until the end of the impression setting time (14). All impressions were stored at 23˚C room temperature for 1 h; thereafter, they were poured with improved type IV stone (GC FUJIROCK, Japan). The improved stone was initially mixed by hand for 10 sec and was mechanically mixed under vacuum for 20 sec. Subsequently, while vibrating, it was poured into the impression and allowed to polymerize for 1 h before the separation. All measurements were taken by a single operator 48 h after the separation. Three different dimensions in the stainless steel model and stone casts were measured at room temperature (23˚C). The dimensions included: 1) Diameter index: the distance between 2 points from intersections between external walls of the internal and the external grooves with 0.5-mm groove in one abutment, 2) Distance index: distance between external walls of external grooves in the point of their intersections with 0.5-mm grooves in 2 abutments from each other, and 3) Height index: the height of the middle vertical groove in one abutment in axial wall (Figure 2). Inter-abutment distances (1 and 3) were determined using the Olympus stereo microscope image on its own software with 12.6 magnification and 10 µm accuracy (OLYMPUS / SZ3060 STU1, USA). The intra-abutment distance was captured with Nikon digital camera (Nikon D3400 w Japan) with 5 µm accuracy and read with the stereo microscope software. Notably, all measurements were repeated three times and the obtained means of the three measurements were used for further analysis. The data were analyzed in SPSS software (version 20.0). The one-way analysis of variance (ANOVA) was used to compare the means. In addition, Dunnett's test was used for multiple mean comparisons with the reference model's dimensions. A p-value less than 0.05 was considered statistically significant.

Results

Table I demonstrates the mean values of impression materials on the stainless steel model in each diameter, distance, and height dimensions using the one-step and two-step impression techniques. The deviations from all impression materials were reported to be within a clinically acceptable range (<90 µm). Regarding the one-step impression technique, one-way ANOVA within each dimension detected statistically significant differences among the three impression materials in distance (F=3.104, P=0.039) and height (F=4.76, P=0.007) dimensions. Nonetheless, no significant difference was detected among the three materials in diameter dimension (F=0.038, P=0.99). Further analysis was carried out for pairwise comparisons between three dimensions of the different materials and the reference model (stainless steel model) in the one-step technique. The results of this analysis revealed statistically significant differences between Panasil impression casts and the reference model in the distance (P=0.021) and height (P=0.009) dimensions (Table II). Nevertheless, no statistically significant differences were observed between Panasil impression casts and the reference model in terms of measured dimensions of Identium and Speedex (Table II). Regarding the two-step impression technique, one-way ANOVA within each dimension revealed statistically significant differences between the three impression materials in distance (F=7.059, P=0.001), height (F=5.011, P=0.005), and diameter (F=3.229, P=0.034) dimensions. In addition, further analysis with Dunnett's test indicated statistically significant differences between Panasil impression casts and the reference model in the height dimension (P=0.004) and between Speedex impression casts and the reference model in the distance (P=0.001) and diameter (P=0.03) dimensions (Table III).

Table I. Mean and standard deviation of stone cast dimensions in mm in each group using one-step and two-step impression techniques

Dimensions	Materials	One-step impression technique (n=10) Mean±SD	Two-step impression technique (n=10) Mean±SD
Distance	Identium	30.827±0.030	30.820±0.051
(30.82)*	Panasil	30.869±0.055	30.830±0.021

	Speedex	30.842±0.048	30.887±0.050
Height	Identium	6.501±0.017	6.503±0.009
(6.5)*	Panasil	6.520±0.019	6.511±0.009
	Speedex	6.514±0.013	6.501±0.006
Diameter	Identium	2.717±0.013	2.720±0.012
(2.72)*	Panasil	2.716±0.013	2.726±0.025
	Speedex	2.721±0.074	2.751±0.044

*Reference's measurements.

Table II. Comparison of means differences in each material dimensions with reference model in one-step impression technique using Dunnett's test

Dimensions	Materials	Mean Difference (Material-Reference)	95% CI	P-value
Distance	**Identium**	0.007	-0.036, 0.050	0.960
	Panasil	0.049*	0.006, 0.093	0.021
	Speedex	0.022	-0.021, 0.065	0.467
Height	**Identium**	0.001	-0.014, 0.016	0.997
	Panasil	0.020*	0.004, 0.035	0.009
	Speedex	0.014	-0.001, 0.029	0.088
Diameter	**Identium**	-0.003	-0.045, 0.039	0.996
	Panasil	-0.004	-0.046, 0.038	0.991
	Speedex	0.000	-0.041, 0.043	1.000

* Statistical difference with the reference model

Table III. Comparison of means differences in each material dimensions with reference model in two-step impression technique using Dunnett's test

Dimensions	Materials	MeanDifference (Material-Reference)	95% CI	P-value
Distance	Identium	0.000	-0.042, 0.042	1.000
	Panasil	0.010	-0.032, 0.052	0.887
	Speedex	0.067*	0.025, 0.109	0.001

Height	Identium	0.003	-0.005, 0.010	0.662
	Panasil	0.011*	0.003, 0.019	0.004
	Speedex	0.001	-0.007, 0.009	0.978
Diameter	Identium	0.000	-0.028, 0.028	1.000
	Panasil	0.006	-0.022, 0.034	0.918
	Speedex	0.031*	0.002, 0.059	0.030

* Statistical difference with the reference model

Discussion

The present study investigated the accuracy of the three different elastomeric impression materials in the one-step and two-step impression techniques. The obtained results indicated that Identium (Vinyl siloxane ether) had the greatest dimensionally accuracy in the one-step and two-step impression techniques with no significant differences in the three dimensions. On the contrary, Panasil was found to have the most dimensional accuracy in a study which compared three impression materials, including Identium, Panasil, and Impregum (polyether) using a 3-dimensional approach (15). In the present study, Panasil (additional silicone) demonstrated a significant increase in distance (49.78 µm) and height (20 µm) dimensions in the one-step impression technique. Moreover, it displayed a significant increase in height dimension (11 µm) in the two-step impression technique, as compared to the reference model. Therefore, the best dimensional accuracy for Panasil was found to be the two-step impression technique. In a similar vein, previous studies have noted that addition silicone as impression material has greater dimensional accuracy in the two-step technique (1, 9). In contrast, Pande and Parkhedkar (16) have indicated that addition silicone as impression material demonstrates greater dimensional accuracy in the one-step, in comparison to the two-step technique. Idris et al. (13) have found statistically significant differences in percentage deviations for both techniques, compared to the reference model among the intra-abutment and inter-abutment distances in addition silicone. In the current study, Speedex (condensation silicone) showed a significant increase in distance (67 µm) and diameter (31 µm) dimensions in the two-step impression technique, as compared to the reference model. Accordingly, it can be concluded that the best dimensional accuracy for Speedex was the one-step impression technique. Nonetheless, Vitti et al. (17) have reported no significant dimensional difference among the impression techniques using condensation silicone (17). Addition silicone materials were found to have the greatest accuracy and stability in a comparative study of ten impression materials of alginate, addition silicone, and condensation silicone (10). In addition, the literature review of dimensional stability and accuracy of silicone-based impression materials using different impression techniques suggested the superiority of the addition silicone over condensation silicone (18). A limited number of studies have compared Vinyl siloxane ether to addition silicone using different impression techniques. Accordingly, further studies are recommended to compare Vinyl siloxane ether to other impression materials using different impression techniques. In the present study, the one-step impression technique was found to be highly accurate in the diameter dimension, as compared to the two-step impression technique. Some studies have also recognized the one-step technique as more accurate (12, 16), while the two-step technique was reported to be superior in other studies (1, 19). On the other hand, some other studies have indicated no significant differences between these two techniques (11, 13). The previous studies have yielded conflicting results regarding the effect of impression techniques on the dimensional accuracy of stone cast. This discrepancy could be attributed to the difference in the materials, protocols, and evaluation methods. Both impression techniques have their own strengths and drawbacks. The one-step technique is easier to perform and economically reasonable. However, there are some concerns regarding the accuracy of this technique. One of the considerations is related to surface defects, such as covering of finish line by heavy body, in a case that the heavy body pushed the light-body wash off the prepared tooth (9, 13). Another problem is the possibility of removing the light-body material from the tooth by patients' tongue when the light body material is on the preparation. Although the two-step technique does not pose these problems, it may cause some concerns during the reseating of the heavy body. In other words, the light-body material can spread along the occlusal surfaces and cause an occlusal step on adjacent teeth. Some distortions are generated during the second step as a result of the displacement of light-body material. These distortions are recognized as a major concern about the reduced dimensional accuracy of the impression in the two-step technique. Furthermore, the increased inter-abutment distances are also reported in the two-step technique due to the displacement of the preliminary heavy body impression during the seating by light body material (9). Every study has some limitations which should be addressed in the paper. In this regard, in the present study, the impressions were not disinfected which may cause possible bias in dimensional accuracy in our results. Moreover, the effect of the oral cavity environment, such as saliva, blood, and soft tissue, was not examined in the current study. Therefore, further studies are recommended to examine the effect of the oral cavity environment on the dimensional accuracy of different impression materials and techniques. Furthermore, it is suggested that additional studies be conducted to investigate the accuracy of the two-step technique without spacer using the ultralight body Vinyl siloxane ether impression.

Conclusion

Considering the limitations of this study and based on the obtained results, all impression materials had an acceptable clinical accuracy. Identium (Vinyl siloxane ether) demonstrated the most accuracy in the one-step and two-step impression techniques. The best accuracy for Panasil (additional silicone) was reported as the two-step impression technique and the best accuracy for Speedex (condensation silicone) was found to be the one-step impression technique. Furthermore, the one-step impression technique was highly accurate in diameter dimension, in comparison to the two-step impression technique. As evidenced by the results, the accuracy of impression is affected by impression technique along with the impression materials. Therefore, the results of the current study are of great help in selecting the proper impression technique and/or material in practice to achieve the best accuracy of impression.

Conflict of Interest:

The authors declare that there is no conflict of Interest.

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