

Comparative Evaluation of the Dimensional Accuracy of Different Putty-Wash Techniques Using Additional Silicon Impression Material In Vitro Study

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Abstract

Purpose: *The aim of the present study was to evaluate and compare the dimensional accuracy of stone models made by addition silicone impression material using three putty- wash impression techniques: one step putty wash (dual viscosity), two step and modified two step putty wash technique.*

Material and Methods: *A stainless steel master model was constructed simulating a three-unit fixed prosthesis. Fifteen impressions were made of this master model with each impression technique. The first technique, one step dual viscosity was made with putty in the tray and light body on brass dies and impression was made. The second technique, two step putty/wash, the first step using putty on the tray with acrylic spacer on the dies and impression was made then followed by loading wash material on the dies and reseating the first impression in the second step. The third technique, modified two step made using putty/light body as in the first technique then a hole was made at the edge of two abutments in the polymerized impression, then light body was loaded into the tray and over the model and the tray is reseated. Total of forty five impressions were obtained and casts poured*

using type IV stone. The accuracy of these casts measured using a travelling microscope. Three dimensions diameter, height, and interabutment distances measurements were obtained and statistical analysis was done using paired T-test, One way ANOVA, and Least Significant Difference (LSD) tests.

Result: *Showed that a significantly larger dimensions of the resultant stone casts of all techniques in comparison to the master model ($P<.01$). The sequence for highest to lowest deviation from the master model was: one step putty wash, two step putty wash, and modified two step putty wash technique.*

Conclusion: *Modified two step and two step putty wash techniques produced most accurate stone casts dimensions, with the privilege of dimensional accuracy shifted to the modified two step impression technique.*

Keywords: *Impression Techniques, Stone Casts, Dimensional Accuracy*

Introduction

Numerous impression materials and techniques have been advocated in order to obtain, as accurate casts, as the preparations in the oral cavity so as to fabricate accurately fitting prostheses [1].

Elastomers were developed as a replacement of natural rubbers during World War II then they were modified chemically and physically for dental use. At first Polysulfide rubbers existed exclusively followed by condensation silicones, Polyether, and then Polyvinyl siloxane [2,3].

The elastomeric impression materials have two main advantages, in good tear resistance and dimensional stability over the earlier impression materials such as the hydrocolloids [4]

The quality of an impression, in turn, is influenced by many factors; namely, the impression technique and its correct application, the impression tray and material combination, local

conditions in the oral cavity (periodontal status, location of the finish line), and, finally, the properties of the impression material used [5,6] .

Impression techniques can be categorized as monophasic or dualphase. Techniques that use dualphase materials such as the putty and light-body may be accomplished in one or two step. The one-step putty/light-body technique requires less chair-side time. In the two-step putty/ light-body technique, the details are recorded by the light-body material only [7].

The main criticism concerning the dual-viscosity one-step technique is the uncontrolled bulk of the light body, whereas in the putty-wash two-step technique, the putty is applied with a spacer, followed by a light body application, thus, controlling the bulk of the wash material [8]

There are several discussions in the dental literature about the effect of material and impression technique on the cast accuracy and prosthesis fitting. Some authors showed that the cast accuracy is affected more by the used impression technique than by the chosen material [8,9,10,11,12]. Other researchers reported that the impression technique does not affect the dimensional accuracy [13,14,15,16,17]. Furthermore, some studies showed better dimensional accuracy when an individual acrylic resin tray is used [18].

The null hypothesis was that the dimensional accuracy of the addition silicon (PVS) impression material would not be affected by the impression technique.

Material and Methods

I Fabrication of the master model

A stainless steel master model with two firmly attached machined brass dies with uniform 6° angle of draw with the vertical axis, was constructed to simulate a three-unit fixed partial prosthesis with one pontic and two identical abutments, as shown in figure I. The abutments were truncated with reference lines on the occlusal and axial surfaces of the abutments, which were used for

measuring the diameter distance, height and interabutment dimension with a travelling microscope (precision Instruments CO.,Delhi) with an accuracy of 0.001 mm or 1 μ m, the dimensions of the master model were shown in table I. The reference lines on the stainless steel master die were measured thrice and the mean value was recorded, as the standard value for each dimension, which acts as a control. The same methods were used for assessing dimensional change of the stone casts in each technique.

II Fabrication of the perforated stock tray

A rectangular perforated stainless steel tray was fabricated. The tray was 2.5 cm width, 5 cm length, and 3.5 cm high, on a base 3 cm wide by 7 cm long, The edges of the tray fit into the 2 mm depth orientation ledges placed on the platform, so that the tray could be repeatedly and consistently seated in a self-limiting way each time an impression was made and there was approximately 7.0 mm clearance between inner surface of the tray and the abutments, as illustrated in figure 1.

III Fabrication of the verticulator assembly

Personally designed device for this study was constructed from stainless steel simulating a verticulator, which consist of the fixed platform (lower part) that secure the master model and upper movable part, that could be moved vertically upward and downward through two vertical rods, and the perforated tray was properly positioned and immobilized in the upper part to allow only vertical movement of the upper part that allow the impression to be removed with straight pull directed along the path of withdrawal of the preparations, the upper part which holding the tray could be locked at any position during its movement by means of side screw knob ensuring stable fixation during impression taking, thus standardizing the impression procedure by ruling out any interference by the operator as shown in Figure 3. The master model was then centralized and fixed to the lower fixed part of the verticulator base by means of two fixation screws.

IV Impression making

All the impressions of the brass master dies were made in the custom made tray, and in controlled room temperature. Impressions were made 15 times for each technique. Impressions were made with addition-reaction silicone impression materials (3M ESPE; Express, GmbH, Germany). The viscosities of the materials used were: putty (Lot 602495, 2017.08, ISO 4823, Type 0, XT Penta Putty), and Light body (Lot N707596, 2018.07, ISO 4823, Type 3, Light body, Fast set). The putty impression material was mixed and dispensed by Pentamix 2 automatic mixing machine (3M ESPE, Germany), and Garant dispenser was used for dispensing light body impression material as shown in figure 4.

Group I: One-step putty/wash technique

Fifteen impressions were taken for the master model using putty and light body impression materials simultaneously, the putty body was mixed with Pentamix machine and injected to the custom perforated tray, while the light body was mixed in Garant dispenser and injected through the nozzle to master model brass dies, then attaching the tray to the upper part of the venticulator and moving it downward and locked in position, as shown in figure 5.

Group II: Two-step putty/wash technique

Fifteen impressions were made by using prefabricated 2-mm thick acrylic resin copings (DuraLay; Reliance Dental Mfg Co, Worth, Ill) placed on each abutment to create a uniform and optimal space for the light-body material. The dimensions of these copings were standardized by using a caliper (#500-181-21; Roder Electronics, Torino, Italy). The preliminary putty impressions were made first and allowed to polymerize for 12 minutes. In the second step, spacer caps were removed from the model and then the light body material was injected over the abutment preparations on the master model with the help of mixing gun. Once the light body material was injected, the tray with putty was again seated over the

master model, and they were allowed to polymerize on the stainless steel model for 12 more minutes.

Group III: Modified two-step putty/wash technique

fifteen impressions were made with putty and light body simultaneously and allowed to set on model for 12 minutes, then on coronal edge of each abutment a hole was made through the set material which coincide with one of the holes present in the custom tray, Extra-light-body material was then added to the primary impression, which was immediately reinserted onto the stainless steel model as shown in Figure 6.

All the impressions were allowed to set on the master model for twice the recommended setting time (12 minutes) in the mouth [7]. This was in order to compensate for the polymerization occurring at room temperature ($25^{\circ}\text{C} \pm 2^{\circ}\text{C}$) rather than mouth temperature ($32^{\circ}\text{C} \pm 2^{\circ}\text{C}$) in accordance with ADA specification No 19. (15-17).

V Working casts

All the impressions were poured in type IV dental stone. A ratio of 11 ml water: 50 gm die stone was used as recommended. The dental stone was hand mixed first for ten seconds, then mixed mechanically under vacuum for twenty seconds. All of the mixes were vibrated (Top; Dentalarm, Torino, Italy) into the impression and allowed to set for one hour before being separated from the impression, as shown in figure 7. This procedure was repeated fifteen times for each impression technique.

VI Measurements

Three different dimensions as illustrated in figure 8, were measured on the stainless steel model at room temperature (control) and on the stone casts from each impression technique: the diameter of abutment, the height of abutment, and the distance

between the centers of the abutments determined by the crossing of the grooves. All of these measurements were made with a travelling microscope. The casts were allowed to air dry for at least 48 hours before measurements were made, and all measurements were made by the same operator. For each of the 3 dimensions on the stainless steel model, the measurements were made 3 times.

Results

Table 2 showed the mean values of the stainless steel model and the means and standard deviation values of the fifteen measurements of each dimension according to the impression technique.

T-test (table 3) was used to compare the dimensional accuracy of the master stainless steel model with the resultant stone casts of different impression techniques, and it showed high significant large dimensions of the stone casts than that of the master model, while the diameter of the two step and height dimension of the modified two step were larger in dimensions but statistically insignificant.

One-way ANOVA test (table 4) revealed a significant difference among all impression techniques in each dimension. Table 5 Post-hoc least significant difference (LSD) test was carried out for comparison between impression techniques in each dimension, it showed that the one step technique had more deviation (larger) in all dimensions of the stone casts than two step and modified two step technique and it was significantly different, while the two step had larger dimensions stone casts than modified two step technique, but it was insignificantly different.

Discussion

In the present study, the accuracy of the resultant casts obtained from 3 different impression techniques was investigated, the 3 different impression techniques, one-step dual viscosity, two-step dual viscosity, and injection two-step dual viscosity technique were used. Impressions of the master model were taken by using costume made perforated metal tray, which keep the distance between tray and the abutments to the minimum to reduce potential cast distortion and produce accurate impression and to ensure that the distance would be fixed in all techniques [19] and for standardization purposes as well. Here, to reduce the number of factors that could have influenced the outcome, the same operator made all impressions.

The pentamix 2 mixing machine was used for the mixing and dispensing of the putty consistency impression material because it provide a precise, a homogenous and void-free mixing since this system eliminates the risks of operator error and allows easy handling [3M ESPE, 2001] .

Moreover, the same materials were used for all of the 3 putty/ light-body techniques considered. Nevertheless, there were noted differences in terms of the accuracy among the different techniques, thus, contradicting previous reports [16,17].

The results of the present study support rejection of the null hypothesis. Significantly Larger mean dimensions in all groups were observed when compared with the dimensions of stainless steel model, and this result agree with Ramandee et al [20], this observation could be due to an expansion of stone material, although the casts were measured 48 hours after the retrieval from the impression. The concept that a similar expansion rate is expected for all specimens would avoid any bias in the comparisons of the accuracy of each impression technique [20].

The results from the 1-step technique was less accurate (significantly different) than the 2-step and modified 2-step

techniques and the latter techniques produced the best results in terms of dimensional accuracy. Tables 5, 6 and 7 findings of this study indicated that the technique used for making the final impression can be a significant factor in determining the accuracy of impressions, The critical factor that influence the accuracy of The 2-step technique is the controlled wash bulk obtained by taking an impression before preparation or by using rigid spacer which is absent in 1-step technique, although the 1-step technique has the advantages of simplicity and allow one impression with two materials; however, in this technique, the putty tends to push the light-body wash off the prepared tooth, and, thus, critical areas, such as the finish line, can be covered by the putty only, which cannot record details to a satisfactory level [21,22]. Furthermore, a simultaneous shrinkage of materials with different viscosities and characteristics occurs. This situation as well as the presence of bubbles in the impression material can occur by excessive pressure applied during the impression and consequent flow of the light-body material [10]. The need of a second person to aid the material handling is another factor to be considered [18].

For this reason, even in studies in which the 1-step technique has been seen to be as accurate as the 2-step technique, so the main critics for this technique was impossible to control the thickness of the light body material [23].

Findings of the present study showed that the dimensions obtained from the modified 2-step technique was seen to be more accurate (insignificantly different) than the 2-step technique, this could be attributed to that during reseating of the tray with light body in the second step of 2 step putty wash technique, the wash induces tension on the high-viscosity material, thus inducing deformation on the already set impression. After setting and on removal, the high-consistency material is likely to exhibit elastic recovery, returning to its original position [13,24,25,26,27], thus resulting in smaller dies and hence a tendency towards larger

interabutment distances. This was observed in a study conducted by Petersen and Asmussen and Negwa et al [27,28].

To address these concerns, the modified 2-step technique, during the first seating of the putty and wash materials it allows the putty to push the wash material unevenly, while in the second step, the light-body material records all of the finer details without being compressed, passive impression could be achieved and excess light body could escape through the vent holes in the polymerized impression material [7].

Conclusion

Within the limitations of this in vitro study, the following conclusions could be drawn:

1. The impression technique affects the dimensional accuracy of the stone casts.
2. Modified two step putty wash impression technique produced the most accurate stone casts with statistically insignificant differences when compared with two step putty wash technique.
3. One step putty wash impression technique produced casts that showed the greatest dimensional variation in all the distances, compared to other groups.

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Table 1: Dimensions of the master model.

Diameter of each die	6.075 mm
Height of each die	7.105 mm
Inter- abutment distance between the centers of two dies	28.515 mm



Figure1: Master Model

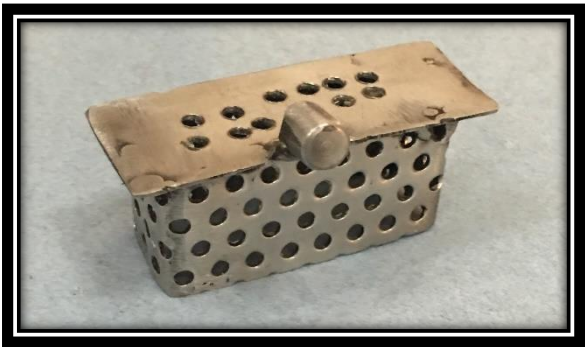
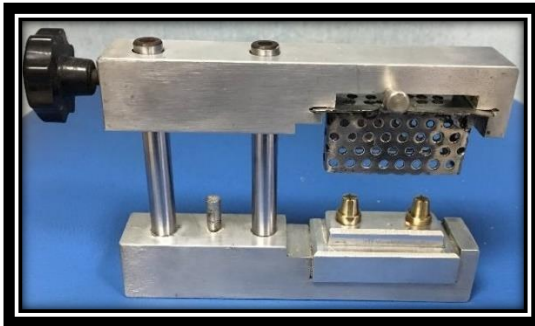
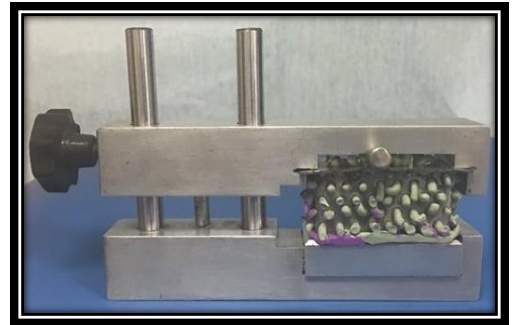


Figure 2: Metal Perforated Tray



A



B

Figure 3: Ventriculator assembly A, Open assembly. B, Closed assembly



Figure 4: Some Materials and Equipment



Figure 5: 1-Step Tech. Impression



Figure 6: Impression Holes for modified 2-step technique

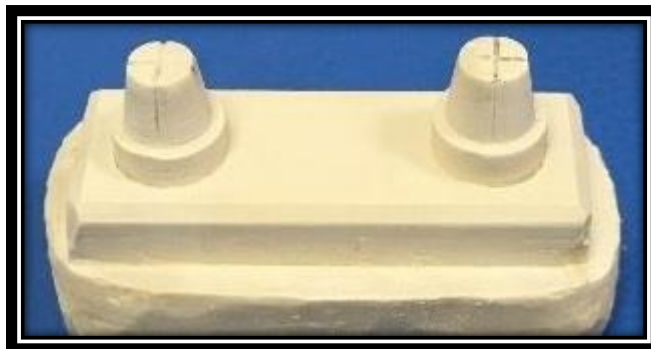


Figure 7: Stone cast

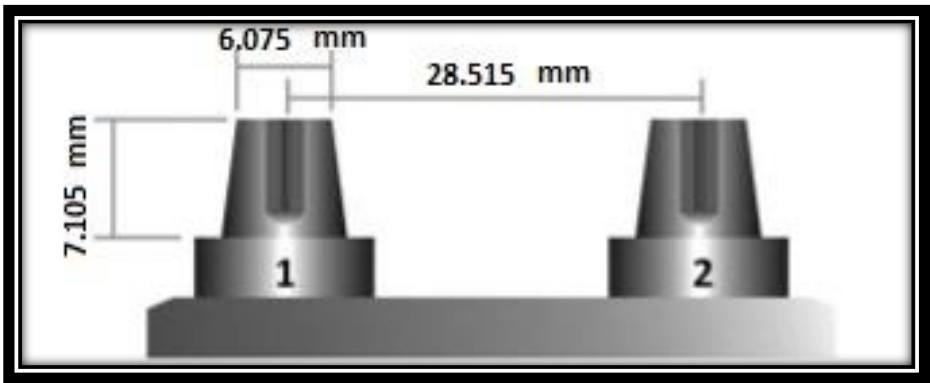


Figure 8: Model Dimensions

Table 2: Means and standard deviations (SD) of the stone casts according to impression techniques.

Dimension (mm)	Model	1-step	2-step	Modified 2-step
Diameter	6.075	6.195 (0.158)	6.053 (0.151)	6.111 (0.152)
Height	7.105	7.132 (0.178)	7.117 (0.177)	7.095 (0.177)
Interabutment Distance	28.515	28.638 (0.715)	28.608 (0.715)	28.598 (0.714)

Table 3: T-test comparison of the dimensional accuracy between the model and stone casts resulted from different impression techniques.

Dimension (mm)	Model	1-step	2-step	Modified 2-step
Diameter	t-test	90.34	5.324	7.454
	P-value	P<0.01 HS	P<0.05 S	P<0.01 HS
Height	t-test	6.857	5.869	5.668
	P-value	P<0.01 HS	P<0.01 HS	P<0.05 S
Interabutment Distance	t-test	23.855	13.685	23.781
	P-value	P<0.01 HS	P<0.01 HS	P<0.01 HS

*P<0.05 Significant

**P<0.001 High significant

Table 4: One-way ANOVA analysis for dimensions of stone casts according to impression technique (n=15)

Dimension	Source	df	Sum of Squares	Mean Square	F	P
Diameter	Between groups	2	.152	.076	3.429	.042 S
	Within groups	42	.932	.022		
	Total	44	1.084			
Height	Between groups	2	.010	.005	4.676	.015 S
	Within groups	42	.047	.001		
	Total	44	.057			
Interabutment Distance	Between groups	3	.013	.006	15.004	.000 HS
	Within groups	56	.018	.000		
	Total	59	.031	.005		

**P<0.05 Significant*

***P<0.001 High significant*

Table 5: Post hoc test, less significant difference for comparisons between the impression techniques with respect to Diameter.

Diameter		Mean difference	P-value	Sig.
1step	2step	.14160*	.013	S
1step	modified	.08407	.030	S
2step	modified	-.05753	.296	NS

**P<0.05 Significant **P>0.05 Non significant*

Table 6: Post hoc test, less significant difference for comparisons between the impression techniques with respect to Height.

Height		Mean difference	P-value	Sig.
1step	2step	.01567	.027	S
1step	modified	.03720*	.004	S
2step	modified	.02153	.085	NS

* $P < 0.05$ Significant ** $P > 0.05$ Non significant

Table 7: Post hoc test, less significant difference for comparisons between the impression techniques with respect to Interabutment distance.

Interabutment distance		Mean difference	P-value	Sig.
1step	2step	.03013*	.000	HS
1step	modified	.03973*	.000	HS
2step	modified	.00960	.212	NS

* $P > 0.05$ Non Significant ** $P < 0.001$ High significant

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المستخلص

الهدف من الدراسة الحالية كان لتقييم ومقارنة دقة ابعاد القوالب الجبسية المصنوعة من طبعة مادة السيلكون باستخدام ثلاث تقنيات لأخذ الطبعة، تقنية ثنائية اللزوجة بمرحلة واحدة، تقنية ثنائية اللزوجة بمرحلتين، والتقنية المعدلة ثنائية اللزوجة بمرحلتين. تم تصنيع قالب رئيسي معدني من الستانليس ستيل ليحاكي طقم ثابت جزئي مكون من ثلاث وحدات، تم اخذ خمسة عشر طبعة للقالب الرئيسي لكل تقنية من التقنيات الثلاث لأخذ الطبعة، التقنية الاولى ذات المرحلة الواحدة وتتضمن وضع مادة السيلكون عالي اللزوجة (عجينة) على وعاء اخذ الطبعه ووضع مادة السيلكون قليل اللزوجة (شبه سائل) على دعامات القالب الرئيسي ومن ثم وضع وعاء الطبعة على القالب وأخذ الطبعة، التقنية الثانية ذات المرحلتين وتتضمن وضع السيلكون عالي اللزوجة على وعاء الطبعة ووضع الفاصل البلاستيكي على الدعامات وأخذ الطبعة وفي المرحلة الثانية يرفع الفاصل البلاستيكي ونضع سيلكون قليل اللزوجة على الدعامات ثم نقوم باعادة وضع الطبعة الاولى على القالب لأخذ الطبعة النهائية، والتقنية الثالثة المعدلة ثنائية اللزوجة تتضمن اخذ طبعه بمادة الطبعة عالية اللزوجة وقليلة اللزوجة في ان واحد كما في التقنية الاولى ومن ثم عمل ثقب على حافة كل دعامة في الطبعة المتصلبة وبعدها يتم وضع مادة الطبعة قليلة اللزوجة على دعامتي القالب ثم يعاد وضع وعاء الطبعة على القالب لأخذ الطبعة النهائية. تقاس دقة ابعاد القوالب الجبسية الناتجة من الطبقات المأخوذة

والبالغ عددها خمسة واربعون بواسطة المجهر المتحرك، يتم قياس ثلاثة ابعاد، طول الدعامة وعرضها وكذلك المسافة بين الدعامتين وتم اجراء تحليل احصائي بأستخدام اختبارات وأختبار انوفا وأختبار الفرق المعنوي الاقل.

أوضحت النتائج اختلاف معنوي يتمثل بكبر ابعاد القوالب الجبسية لكل التقنيات مقارنة بأبعاد دعامات القالب المعدني، التقنية الاولى اظهرت اختلاف معنوي كبير تليها بنسبة اقل التقنية الثانية تليها التقنية الثالثة.

يستنتج من الدراسة ان تقنية الطبعة ثنائية اللزوجة ذات المرحلتين والتقنية المعدلة ثنائية اللزوجة ذات المرحلتين انتجت قوالب جبسية عالية الدقة، وكانت دقة ابعاد القوالب الجبسية المنتجة من التقنية المعدلة افضل.

الكلمات الرئيسية: تقنيات الطبعة، القوالب الجبسية، دقة الأبعاد.