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EVALUATION OF ACCURACY OF NOVEL APPROACH FOR THE USE OF SILICONE IMPRESSION MATERIALS. A COMPARATIVE IN-VITRO STUDY

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ABSTRACT

Introduction: Accurate impression is one of the most critical factors affecting the success of the dental prosthesis. With shortage of many dental materials in Egypt lately, Impression making with intermixing of addition and condensation silicone impression was suggested and needed to be tested for validation.

Aim: Evaluation of the accuracy of intermix technique of silicone impression materials in terms of trueness and precision.

Materials and methods: Fifteen impressions of two step putty/wash impression technique were made for Acrylic dentulous model with #14 had full coverage crown preparation and divided into in 3 groups; group A, condensation silicone, group B, intermix of light body addition silicone over putty condensation and group C, addition silicone. 3D superimposition of STL files of scanned models were made in order to evaluate trueness and precision.

Results: Addition silicone had the best trueness followed by condensation silicone and intermix group. Significant difference was found between addition silicone and intermix group but no significant difference was found between intermix group and condensation silicone as well as between addition and condensation silicones. In matter of precision, condensation silicone had best mean deviation value then addition silicone and intermix group. No significant difference was found between the three groups.

Conclusion: Intermix technique proved to be a valid option in impression making within limitations of this study. Further studies should be made with bigger sample size and other testing environment.

KEYWORDS: Impression, silicone, accuracy, trueness, precision

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INTRODUCTION

A successful dental prosthesis is dependent on the perfection of many steps in the dental office and impression making is considered the most critical step among all[1]. Impression is a negative likeness or copy in reverse of the surface of an object; an imprint of the teeth and adjacent structures for use in dentistry[2]. Making impressions to replicate oral conditions and tooth morphology is an integral part of prosthetic dentistry. Various materials have been used to make impressions for removable and fixed prosthodontics[3]. Elastomeric impression materials like polysulfide, silicone and polyether remains the most popular and accepted material among dentists.

Silicone impression materials are available in two types; condensation silicone and addition silicone. Condensation silicone is obtained by cross-linking polycondensation reaction of hydroxyl terminated polysiloxane pre-polymers with tetra alkoxy silanes catalyzed by dibutyl-tin dilaurate, (DBTD). Condensation silicone materials provide precise impression if poured quickly after it is taken as well as good elastic restoration after removal from patient`s mouth. However, they are hydrophobic, with time dimensional changes begin and the catalyst may develop an allergic reaction[8].

Addition silicone is obtained by cross-linking polyaddition reaction of vinyl terminal polysiloxane polymers with mediation of methylhydrogen silicone as cross-reacting agent in the presence of platinum catalyst. Addition silicone materials provide precise impression, high elasticity, dimensional stability, not providing allergic reaction. However they are: hydrophobic, inhibited by latex gloves and defects may be developed after casting by the release of hydrogen[8]. Recently, addition silicone impression materials are provided in hydrophilic form by addition of extrinsic surfactants which enhance the wettability of oral tissue during impression making[22]

These impression materials are available in different viscosities: extra-light body[21], light body, medium body, heavy body, and very heavy body (putty consistency). These various viscosities allow them to be used in two-impression techniques: (1) single step and (2) dual step. The dual-step technique includes two-step putty/light body, two-step heavy/light body, and two-step medium/light body[4]. All these impression techniques affect the dimensional precision of stone models in a different manner.

During the latest economic crisis in Egypt, the dental market suffered a shortage of many dental products, among which were the impression materials[5]. Dental practitioners have to overcome such shortage via different approaches, from these approaches there was one which was noticed to achieve a good results. This approach includes the intermixing between addition and condensation silicones, where light body of addition silicon was used over the putty of the condensation silicon in a two-step putty/wash impression technique. This technique was developed to achieve impression with the best details in times when, there lack of availability of putty form of addition silicon in the market.

Accuracy is one of the most crucial qualities of the impression materials, it determines the precise fabrication of dental prosthetics. Evaluation of accuracy of the impression material is made through evaluation of its trueness and precision[13, 16], which is recently carried out by 3-dimensional (3D) assessments through superimposition.

Superimposition of 3D digital dental models to evaluate the accuracy of the impressions has been made in the literature[7] through several computer software programs and techniques have been introduced in recent years to allow for digital superimposition of two or more such 3D models[6].

The aim of this study was to evaluate of the dimensional accuracy of silicone impression materials through a novel approach of using the light body of addition silicon impression material over the putty form of condensation silicon impression material in two-step technique and compare it with the traditional two-step putty/ wash impression techniques in terms of trueness and precision.

MATERIALS AND METHODS

In this in vitro study, a readymade model of mandibular arch was used with synthetic-resin teeth (A-3, Frasaco®, Germany) with full coverage crown preparation in tooth #14 (figure 1). Impressions were made for this model in a two- step putty/light body technique in the following manner;

a- Group A: Putty condensation silicon /light body condensation silicon.

b- Group B: Putty condensation silicon /light body addition silicon. (intermix group)

c- Group C: Putty addition silicon /light body addition silicon.

Sample size was calculated based on previous studies[13,14], for each group five impressions were made using a metal tray and 25-40 microns thick cellophane sheet spacer was used in the two step impression technique for all groups[1,3,17]. However in group B, one layer of adhesive (adhesive Coltène®, Whaledent, Germany) (figure 2) was applied on the surface of the putty codensation silicon(Speedex Coltène®, Whaledent, Germany) in order to ensure attachment between it and the light body additional silicon (Affinis Coltène® Whaledent, Germany). One operator (A. H.) performed the impressions following the manufacturers' instructions regarding the material's setting time and handling, but the waiting time was set to compensate for the temperature difference between the environment and the oral cavity's mean temperature by making it twice the manufacturer's recommended setting time[15]. Five models for each group were obtained from pouring with extra hard stone material type IV (Dental Stone A Hard; Zeta, Italy).

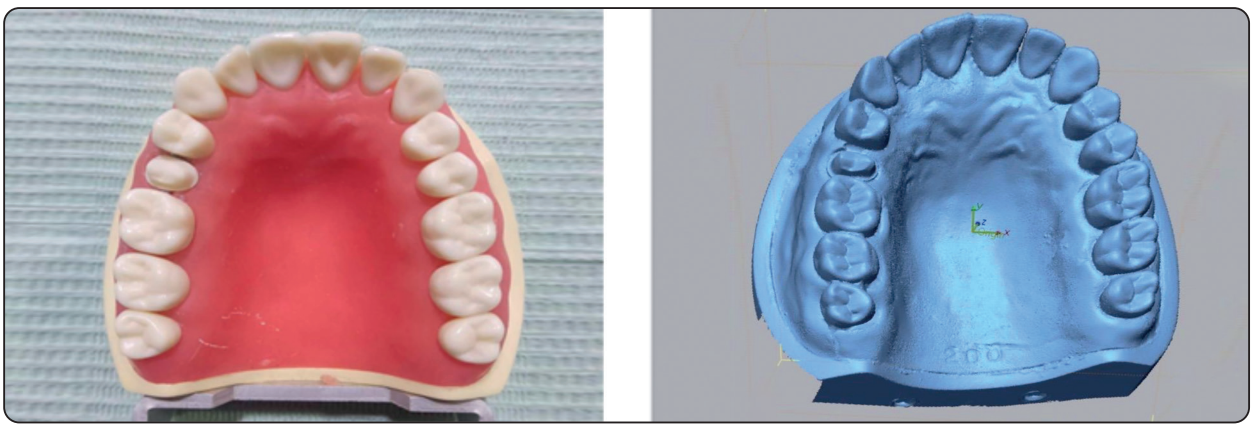

Fig. (1) Original model with tooth #14 prepared for full crown restoration.

Fig. (2) Polysiloxane adhesive.

Extra-oral lab scanner (FREEDOMHD lab scanner DOF® South Korea) was used to scan the original model as well as the fifteen models of the three groups. The STL files obtained were evaluated with a 3D analysis software (Geomagic Control X, 3D Systems) by previously described methodology, being successively superimposed on the standard STL, using the dental surfaces as reference for the 3D superimposition and best-fit alignment[11,12]. The software was used to calculate the 3D deviation of each cast by the use of the root mean square (RMS) error. (Figure 3)

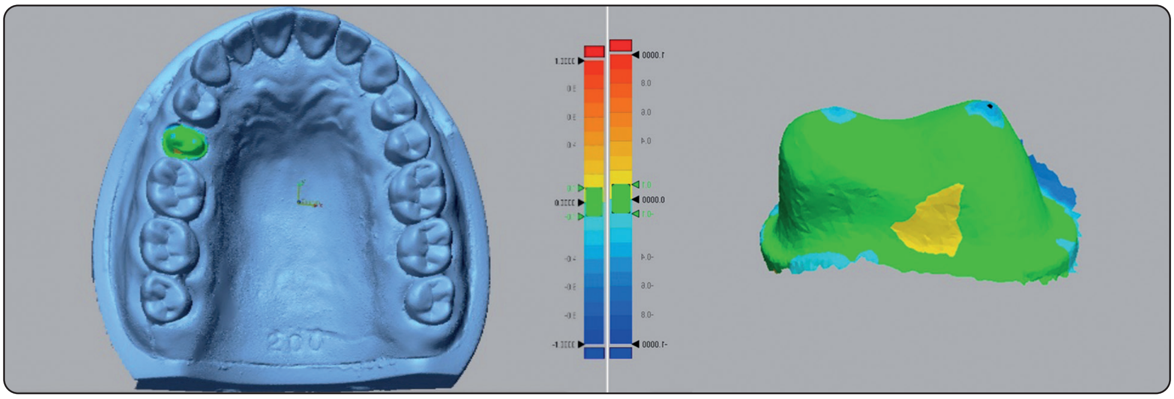

Fig. (3) Representation of the color map of superimpositions of scanned models, Nominal max/min ±100 µm (green). Critical max/min ±1000 µm (dark red and dark blue)

The data were analyzed with prism graph pad 10.2.0 software. Ordinary one-way ANOVA was used to compare the deviation of models of each group from the original model to evaluate accuracy, Tukey's HSD test was used for multiple paired comparison between the three groups. The results were reported with a 95% confidence interval.

RESULTS

Trueness Analysis

Analyzing the mean deviation in μm of each group from the original model showed that, group B (light body addition over putty condensation silicones) had the greatest deviation from original model 158.7±61.57, followed by group A (light and putty condensation silicone) 96.08±21.99 and group C (light and putty addition silicone) had the least deviation from original model figure 4. One way ANOVA revealed that, there was a significant difference (P<0.05) between the three groups (Table 1).

TABLE (1) Comparison between mean dimensional deviations between three groups from original model (Trueness).

	Group A	Group B	Group C	F value	P value
Deviation in μm	96.08 ±21.99	158.7 ±61.57	85.3 ±32.27	4.436	0.0361*

Significant diff. among means (P < 0.05)

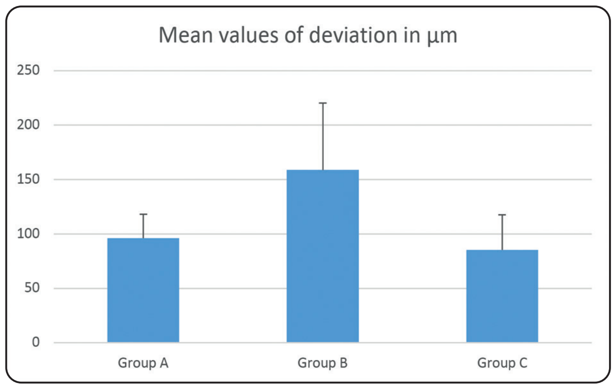

Fig. (4) Mean values of trueness for the three groups.

Further analysis using Tukey multiple comparison test, paired comparison showed that there was no significant difference between group A (light and putty condensation silicone) and group B (light body addition over putty condensation silicones) and also no significant difference between group A (light and putty condensation silicone) and group C (light and putty addition silicone). However there was a significant difference between group B (light body addition over putty condensation silicones) and group C (light and putty addition) (P < 0.05) Table 2.

Precession Analysis

Analyzing the mean deviations in μm between models within each group showed that, group B (light body addition over putty condensation silicones) had the greatest deviation from original model 90.45±33.52, followed by group C (light and putty addition silicone) 54.60±14.09 and group A (light and putty condensation silicone) had the least deviation from original model figure 5. One way ANOVA revealed that, there was no significant difference (P = 0.1276) between the three groups. Table 3

Further analysis using Tukey multiple comparison test, paired comparison showed that there was no significant difference between three groups (P > 0.05). Table 4

TABLE (2) Paired comparison between mean dimensional deviations of three groups from original model.

	Mean± SD	Mean Difference	95.00% CI of diff.	P Value
Group A	96.08±21.99	-62.64	-133.7 to 8.380	0.0862
Group B	158.7± 61.57			
Group A	96.08±21.99	10.78	-60.24 to 81.80	0.9142
Group C	85.3±32.27			
Group B	158.7± 61.57	73.42	2.4 to 144.4	0.0426*
Group C	85.3±32.27			

Significant diff. among means (P < 0.05)

TABLE (3) Comparison between mean intergroup dimensional deviations between three groups (Precision).

	Group A	Group B	Group C	F value	P value
Deviation in μm	54.60±14.09	90.45± 33.52	63.13±17.04	2.610	0.1276

Significant diff. among means (P < 0.05)

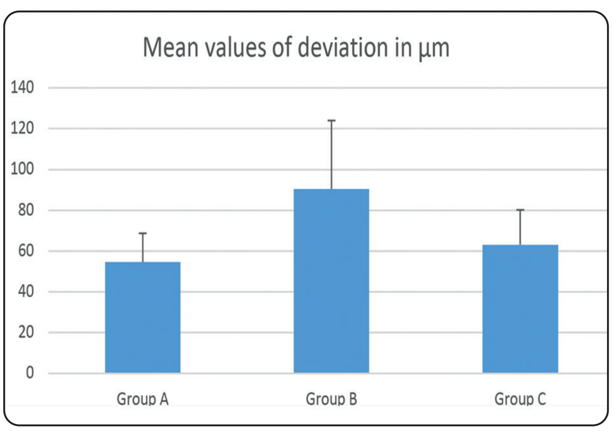

Fig. (5) Mean values of precision for the three groups.

TABLE (4) Paired comparison between mean dimensional deviations of three groups from original model.

	Mean± SD	Mean Difference	95.00% CI of diff.	P Value
Group A	54.60±14.09	-35.85	-81.62 to 9.923	0.1271
Group B	90.45± 33.52			
Group A	54.60±14.09	-8.525	-54.30 to 37.25	0.8637
Group C	63.13±17.04			
Group B	90.45± 33.52	27.33	-18.45 to 73.10	0.2692
Group C	63.13±17.04			

Significant diff. among means (P < 0.05)

DISCUSSION

This in vitro study was made in order to evaluate the trueness and precision of the three groups in order to assess the dimensional accuracy. Two step impression technique was used because, it was reported that it may represent more dimensional details that one step technique[3,18]. As well as to be able to apply the adhesive in group B for attachment of light body to putty consistencies of dissimilar materials.

Although using acrylic dental model may not fully simulate the true dental arch situation as scanner's accuracy may be affected by the variations in the dental arches' geometry[20], however subsiding intraoral factors as saliva and patient's movement during scanning is essential for standardization of the scanning procedures[7].

Two step putty-wash impression technique was used because of its simple procedures[31], does no need of a custom tray thus saving a lot of clinical and laboratory time[17]and reported to provides better dimensional accuracy by reducing the amount of polymerized material at each step hence, the final contraction can be decreased[32]. Also was more convenient for application of the adhesive in between light body and putty in the intermix technique.

According to manufacturers` instructions, intermix between condensation and addition silicone is not recommended due to the difference of chemical composition that may not guarantee correct adhesion between them, however impression adhesive might provide a solution for this issue.it was mentioned that coltene® adhesive provided adequate adhesion with both addition and condensation silicone[17,23], despite the fact that the study was on adhesion of silicone impression materials to different trays but it might be considered for adhesion between impression layers in putty/ wash two step technique.

In this study extra oral lab scanner were used for scanning of models because, it was reported that that extraoral scanners offer better results than intraoral scanners [7,24,25]. Although other studies mentioned that both types of scanners have almost the same quality[26].

To assess the accuracy between the STL files a 3D analysis software (Geomagic X) was used in order to have the best-fit superimposition of models for both trueness and percesion[19,20]. Study's assessments were made in 3D instead of 2D as it was reported that, these methods take more time, and require extra effort to analyze the data, but without doubt they more accurate for evaluation of accuracy and dimensional stability of the impression material[9].

Regarding trueness, results of this study showed that there was a significant difference between the three groups where addition silicone achieved the best dimensional trueness with mean deviation 85.3±32.27 μm which is consistent with the literature[27-29]. However multiple comparisons by tukey post hoc test revealed there no significant difference between addition and condensation silicone which agreed with a study[27], which didn't find significant difference between both materials in their in vitro 3D analysis of elastomeric impression materials. On the other hand some studies[28,30] reported a significant difference in comparison between addition and condensation silicones despite the fact that both had satisfactory dimensional accuracy and stability.

The intermix technique of addition and condensation silicone represented by group B showed a significant difference when compared to addition silicone, this may be attributed to the difference in contraction between addition and condensation silicone. However it didn't show a significant difference when compared to condensation silicone which gives a promising point for this technique.

Regarding precession, the results showed that condensation silicone had the least mean deviation 54.60±14.09 μm when the five models were compared to each other by superimposion followed by addition silicone 63.13±17.04 and the greatest mean deviation was the intermix technique group B with mean deviation 90.45± 33.52. No significant difference was found between the three groups, which means that to some extent the intermix technique is reliable for impression making especially in some situation where a hydrophilic impression material is needed such as sub gingival preparation where moisture affect hydrophobic impression materials` polymerization decreasing their dimensional accuracy in comparison with hydrophilic impression materials[32].

CONCLUSION

Within the limitations of this study it can be concluded that:

- Addition silicone provided the best trueness among the three groups.
- No significant difference between condensation silicone and intermix technique.
- No significant difference between 3 groups in term of precision.
- The intermix technique proved to be a valid option in impression making.
- Further studies are recommended to evaluate the intermix technique in terms of sample size and testing environment.

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