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Comparative Evaluation of Dimensional Accuracy of Polyvinyl Siloxane Impression Materials Using Two Different Impression Techniques: An In Vitro Study

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ABSTRACT:

AIM OF THE STUDY: To evaluate the dimensional accuracy of polyvinyl siloxane impression materials using two different impression techniques.

METHODOLOGY: A Stainless steel die was made according to ADA specification no. 19 for non aqueous elastic dental impression materials. Three brands of polyvinyl siloxane impression materials used were Aquasil, Flexceed and Imprint II Garant. Two impression techniques used were Double mix and Single mix impression technique. A total of 60 specimens were prepared and the dimensional accuracy was evaluated after 24hrs using Profile Projector.

STATISTICAL ANALYSIS: The data was analysed using one-way analyses of variance and significant differences were separated using Student′s Newman- Keul′s test.

RESULT: When all the three study group impression materials were compared for Double mix technique, statistically significant difference was found only between Imprint II Garant and Flexceed ($p<0.05$). Similarly, using Single mix technique, statistically significant difference was found between Flexceed and Imprint II Garant ($p<0.05$) and also between Aquasil and Flexceed($p<0.05$).When the dimensional accuracy of all three impression materials in double mix impression technique and single mix impression technique were compared Imprint II Garant showed the least dimensional changes from the master die, followed by Aquasil and Flexceed respectively.

Conclusion: Double mix impression technique showed better results than single mix impression technique andamong the impression materials Imprint II Garant showed least dimensional change.

Key Words: Polyviny siloxane, Double mix impression technique, Impression materials, Single mix impression technique, Dimensional accuracy.

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INTRODUCTION

The ultimate goal of a dental impression is to produce an exact negative replica in three dimensions, of the soft and hard tissues of the oral cavity. High accuracy of dental impression is the mandatory first step and an integral step in a complex process of fabricating a well-fitting indirect dental restoration.[1] Since the patients soft and hard tissues are transferred, having anatomic knowledge about periodontal tissues, making an accurate impression especially in the finish line, and using proper impression materials and an appropriate impression technique are important in making a suitable and accurate impression. The accuracy of impression techniques is judged on basis of marginal adaptation and minimum gap obtained. The bonding and mechanical characteristics are also significantly influenced by marginal fit.[2]

Clinically, elastic impression materials are available in various forms for dental use. They can be divided into two large groups:(1)synthetic elastomeric impression materials that include polysulphide, condensation silicone, addition silicone and polyether.(2) Hydrocolloid impression materials like agar-agar and alginate impression materials[3].

Dimensionally stable and accurate impressions are the first step towards fabrication of a successful prosthesis. Elastomeric impression materials have emerged as the material of choice for a variety of reasons including dimensional stability and excellent reproducibility.[4]In1950, the first synthetic elastomeric impression material launched was polysulphide. Its elasticity was sufficient for it to be removed from retentive areas.

Polyether was the first elastomeric material developed to be used in dentistry in 1965, while the others were first used in industry. In 1975 Addition silicones were launched having good characteristics.[5]

Addition reaction silicones also known as Polyvinylsiloxane impression materials became extremely popular during the past decade. Although they are among the most expensive impression materials, they are now used in a wide variety of situations in operative dentistry, removable prosthodontics, fixed prosthodontics and implant dentistry due to their excellent handling characteristics, physical properties and unlimited dimensional stability.[6]

Polyvinyl siloxane is found in different viscosities (from very low to very high viscosity materials), making it possible to use in different impression techniques: putty wash one-step (simultaneous impression technique), regular one step (single phase) and putty wash two-step (reline impression technique). Elastomeric materials may show dimensional changes due to many factors such as polymerization shrinkage, hydrophilicity, by product evaporation from polymerization reaction, shrinkage from thermal alteration, mishandling, thickness and adhesion of material to the tray.[7]

In the past various studies have been conducted and few authors have reported that the accuracy of addition silicone was affected rather by type of material than the technique while others have stated that accuracy may be controlled more with technique than by the material itself.

So, the aim of this study was to compare the dimensional accuracy of three brands of PVS impression materials and to evaluate the most accurate impression technique.

METHODOLOGY:

Impression material used(Fig;1):

1. Aquasil (Dentsply/ Caulk, USA) hydrophilic addition reaction silicone.
2. Flexceed(GC,Japan)vinyl polysiloxane.
3. Imprint II Garant (3M ESPE, Germany) vinyl polysiloxane.

Armamentarium:

1. Stainless steel die with horizontal and vertical lines(ADA Specification no.19)
2. A Brass metal plate(thickness 1.5mm and diameter 29.9mm)
3. Flat glass plate(wt. 67g)
4. Polyethylene sheet
5. Automixing impression gun(3M ESPE).
6. Thermostatically controlled water bath(32±2°C)
7. Profile Projector.

Method of Impression making:

In this study two different impression techniques were used:

1. Method A- Double mix impression technique.
2. Method B- Single mix impression technique.

Fabrication of Stainless Steel Die:

A stainless steel die was made according to ADA specification no.19 (Fig; 2-3). Die had a ruled block and mold (Fig; 4). Ruled block had a height of 31 mm with diameter of inner ring and outer ring 29.9mm and 38 mm respectively. Mold had 30 mm inner ring and 38 mm outer ring with a height of 6mm. It serves as a tray for containing the impression material. With the help of Nd-YAG laser treatment, three vertical lines of width 0.016mm were made on the ruled block, which were labelled as X, Y, Z. The distance between two consecutive vertical lines was being 2.5 mm. Two horizontal lines were scored intersecting the vertical lines on either side with a distance of 25 mm between them. The intersection of vertical and horizontal line Y was marked as Q and Q′ and served as the start and end points of measurements for dimensional accuracy (Fig;5). A brass metal plate of thickness 1.5 mm, height 3mm and diameter of 29.9mm was also made to be used as a spacer to create uniform space for light bodied wash impression material for the specimens made using method A.

Manipulation of materials:

Specimen fabrication for all three study group materials using method A:

For making impressions using double mix impression technique, a Brass metal plate of thickness 1.5 mm and diameter of 29.9mm (to create uniform space for light body material) was placed in the mold. Preliminary impression was first made using soft putty and was allowed to polymerize for 12 minutes.A Flat glass plate (of weight 67g) was placed on top of the mold to keep the impression material within it and to apply the sufficient force. Allow the putty material to harden. Then brass metal plate and putty impression was taken out and light bodied wash impression material was applied to the die space created

by 1.5 mm thickness metal plate. To minimize the voids, the tip was kept in contact with the lined areas of the metal die and then the impression material was pushed ahead of syringe tip in a Zig-zag pattern. A polyethylene sheet and a flat glass plate was placed on top of the mold. The assembly was immediately transferred to the thermostatically controlled water bath for 13min. 600g weight was placed on top of the flat glass plate to ensure that the die did not move and to maintain adequate pressure to record the detail production of the scribed lines of the mold. The water bath was temperature maintained at 32 ± 2°C to simulate oral conditions in accordance with ADA specification number 19.

Specimen fabrication for all three study group materials using method B:

For making impressions using single mix impression technique light body was applied to the lined area of the die. Simultaneously, soft putty was mixed with finger tips for 30 seconds until the color was uniform and was placed on the light body. A polyethylene sheet and a flat glass plate (of weight 67 g) wasplaced on top of the mold to keep the impression material within the mold and to apply sufficient force. The assembly was immediately transferred to the thermostatically controlled water bath for 13min. 600g weight was placed on top of the flat glass plate to ensure that the die did not move and to maintain adequate pressure to record the detail production of the scribed lines of the mold.The water bath was temperature maintained at 32 ± 2°C to simulate oral conditions in accordance with ADA specification number 19.

Grouping of test samples:

The 60 test samples were divided into 3 groups of 20 samples each, which were then employed for evaluating dimensional stability.

- Group 1: Consists of 20 specimens made using Aquasil polyvinyl siloxane impression material
- Group 2: Consists of 20 specimens made using Flexceed polyvinyl siloxane impression material
- Group 3: Consists of 20 specimens made using Imprint II Garant polyvinyl siloxane impression material

20 samples of each group were further divided into two subgroups of 10 specimens each which were designated as:

Group 1A: consists of 10 specimens made using Aquasil polyvinyl siloxaneimpression material by using Double mix technique.

Group 1B: consists of 10 specimens made using Aquasil polyvinyl siloxane impression material by using Single mix technique.

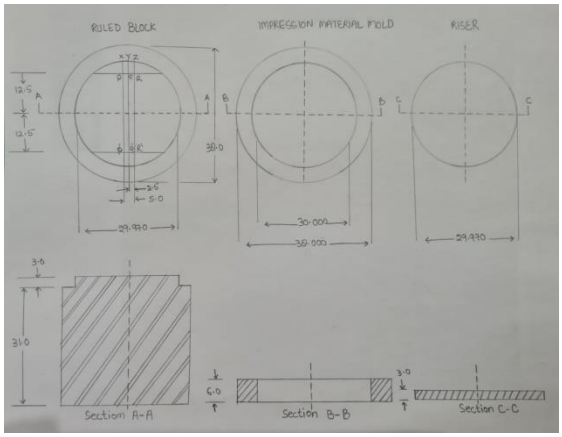
Group 2A: consists of 10 specimens made using Flexceed polyvinyl siloxane impression material by using Double mix technique.

Group2B: consists of 10 specimens made using Flexceed polyvinyl siloxane impression material by using Single mix technique.

Group 3A: consists of 10 specimens made using Imprint II Garant polyvinyl siloxane impression material using Double mix technique.

Group 3B: consists of 10 specimens made using Imprint II Garant polyvinyl siloxane impression material using Single mix technique.

Figure 1: Impression materials used.



Section A-A: Ruled block

Section B-B: Impression material mold

Section C-C: Riser (brass metal plate)

(all measurements in mm)

Figure 2: Schematic diagram showing ADAspecification number 19 detail reproduction block.

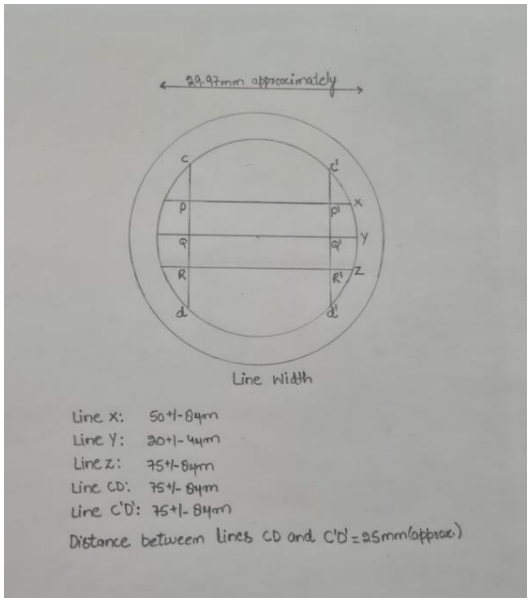


Figure 3: Schematic diagram showing ruled surface of the metal Die.

Figure 4: Stainless Steel Test Die

Figure 5: Stainless steel die with 3 vertical lines (X,Y,Z) and 2 horizontal lines. Intersection of cross lines Q and Q′ served as beginning and end points of line used for measurement of dimensional accuracy.

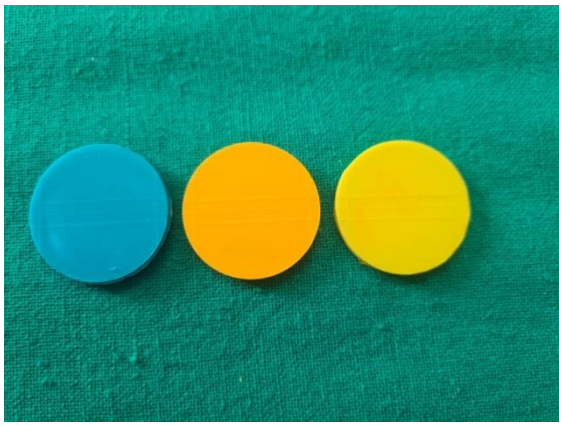


Figure 6: Each impression material specimens made using Double mix impression technique.

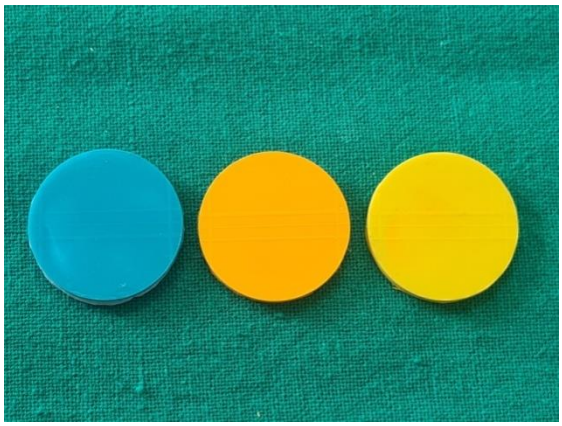


Figure 7: Each impression material specimens made using single mix impression technique

Figure 8: Profile Projector (Radical RPP-3000)

Recovery of test specimens:

The die, polyethylene sheet, flat glass plate and weight were removed from the water bath after 13 min. The impressions were allowed to set for 5 min longer than the manufacturers recommended minimal removal time, as indicated in ADA specification Number 19 for lab testing. The mold and brass metal plate were then separated, and the impression was retrieved. All the specimens were numbered group wise for measuring dimensional accuracy (Fig; 6-7)

Evaluation of Dimensional accuracy:

After 24hrs of impression making the dimensional accuracy was evaluated. The length of the line "Y" between cross points "Q" and "Q′" of each impression sample was measured.This measurement was made thrice for each sample using Profile Projector to the nearest of 0.001 mm at ×10magnification(Fig;8). All the readings thus obtained were tabulated and subjected to statistical analysis.

Statistical analysis: Data was analysed using the statistical package **SPSS 26.0** (SPSS Inc., Chicago, IL) and level of significance was set at **p<0.05**. **Descriptive statistics** was performed toassess the mean and standard deviation of the respective groups. Normality of the data was assessed using **Shapiro Wilkinson test**. **Inferential statistics** to find out the **intra group comparision**was done using **repeated measures of ANOVA and STUDENTS NEWMAN KEULS test. Inter group comparision using INDEPENDENT T test** to find out the difference between any two groups

RESULTS

In the present study the Dimensional accuracy was analysed for three different types of Polyvinyl Siloxane Impression materials after 24hrs.

Table 1: shows the descriptive details of Group A/ Double Mix impression technique. Within double mix group the lowest dimensional change (0.15) was observed with Imprint II Garant followed by Aquasil (0.17) and highest values were observed with Flexceed (0.23). So, the dimensional change observed with the three materials was:

Imprint II Garant <Aquasil< Flexceed

TABLE 2: shows the descriptive details of Group B/ Single Mix impression technique. Within single mix group, Imprint II Garant the lowest dimensional change (0.16) followed by Aquasil (0.18) and highest values were observed with Flexceed (0.24). So, the accuracy observed within the three materials was as follows:

Imprint II Garant <Aquasil< Flexceed

TABLE 3: this table shows the intragroup comparison of Double mix impression technique. Intragroup comparison using repeated measures of ANOVA analysis followed by POSTHOC test reported statistically significant difference after 24hr time interval (P<0.05) except for the group 1A vs 3A (P>0.05).

Imprint II Garant was found to be best with least dimensional change followed by Aquasil and Flexceed.

TABLE 4: shows the intragroup comparison of Single mix impression technique. Intragroup comparison using repeated measures of ANOVA analysis followed by POSTHOC test reported statistically significant difference after 24hr time interval (P<0.05) except for the group 1B vs. 3B (P>0.05)

Imprint II Garant was found to be best with least dimensional change followed by Aquasil and Flexceed.

TABLE 5: shows the intergroup comparison between Single mix against Double mix impression technique. When the analysis was done using INDEPENDENT T- test, statistical insignificance (P>0.05) was reported with respect to all the three impression materials.

Double mix group showed lesser dimensional change values as compared to single mix group.

Hence, from the results it was concluded that Imprint II Garant was more accurate followed by Aquasil and Flexceed impression material but there was no statistically significant difference between Imprint II Garant and Aquasil impression material.

TABLE 1- DESCRIPTIVE DATA OF DOUBLE MIX GROUP

		MEAN	SD	MIN	MAX	STD ERROR
GROUP A	GROUP 1A	0.17	0.02	0.14	0.19	0.001
	GROUP 2A	0.23	0.01	0.18	0.26	0.001
	GROUP 3A	0.15	0.03	0.14	0.18	0.001

TABLE 2- DESCRIPTIVE DATA OF SINGLE MIX GROUP

		MEAN	SD	MIN	MAX	STD ERROR
GROUP B	GROUP 1B	0.18	0.04	0.16	0.19	0.001
	GROUP 2B	0.24	0.04	0.22	0.26	0.001
	GROUP 3B	0.16	0.03	0.14	0.18	0.001

TABLE 3- INTRA GROUP COMPARISION WITHIN DOUBLE MIX REGARDING THREE STUDY MATERIALS (ALL VALUES IN MM)

		MEAN	SD
GROUP A	GROUP 1A	0.17	0.02
	GROUP 2A	0.23	0.01
	GROUP 3A	0.15	0.03
P VALUE (REPEATED MEASURES OF ANOVA TEST)		0.0001*(F=15.48)	
P VALUE (POSTHOC STUDENT'S NEWMAN KEULS)	1A vs 2A	0.0001*	
	1A vs 3A	0.11	
	2A vs 3A	0.0001*	

***P<0.05 is statistically significant**

TABLE 4- INTRA GROUP COMPARISON WITHIN SINGLE MIX REGARDING THREE STUDY MATERIALS (ALL VALUES IN MM)

		MEAN	SD
GROUP B	GROUP 1B	0.18	0.04
	GROUP 2B	0.24	0.04
	GROUP 3B	0.16	0.03
P VALUE (REPEATED MEASURES OF ANOVA TEST)		0.0001*(F=20.48)	
P VALUE (POSTHOC STUDENT'S NEWMAN KEULS)	1B vs 2B	0.001*	
	1B vs 3B	0.45	
	2B vs 3B	0.0001*	

***P<0.05 is statistically significant**

TABLE 5 – INTER GROUP COMPARISON BETWEEN DOUBLE MIX AND SINGLE MIX TECHNIQUES REGARDING THREE STUDY MATERIALS (ALL VALUES IN MM)

	GROUP A	GROUP B	T VALUE	P VALUE (T TEST)
GROUP 1A vs GROUP 1B	0.17±0.02	0.18±0.04	0.70	0.48
GROUP 2A vs GROUP 2B	0.23±0.01	0.24±0.01	1.41	0.17
GROUP 3A vs GROUP 3B	0.15±0.03	0.16±0.03	0.74	0.46

***P<0.05 is statistically significant**

DISCUSSION:

Making an Impression is a critical step in the process of fabricating successful crowns and bridges. Any inaccuracy in the impression making will ultimately have an adverse effect on the fit and adaptation of the final restoration as precise fitting of casting is obtained in five steps beginning from tooth preparation, impression making, wax pattern, investment and finishing of the casting. The impression material is used in the first phase, and any inaccuracy is carried through to the finished casting **(Petrie et al 2003)[8].**

Polyvinyl siloxane impression materials, also known as addition reaction silicones, became extremely popular during the past decade. Addition reaction silicone impression materials

have excellent physical properties. Their accuracy is unsurpassed and they can record fine detail. They also have the bestelastic recovery of all available impression materials[9].Becausethereisvirtuallynoby-producttothepolymerization reaction, impressions are dimensionally stable and can be pouredattheconvenience of the operator. They also allow the opportunity to make multiple pours[10].The handling characteristics of addition reaction silicones are also favorable. They are supplied in a number of viscosities, ranging from very low for use with asyringe or wash material to medium, high, and very high. This allows these materials to be used for a host of applications. Polyvinyl siloxane materials are supplied by many manufacturers in the automix system, which is convenient, providesaconsistentmix,andiscost-effective[11]. The number of bubbles incorporated in the mix is reduced with the automix system. From a patient comfort standpoint, these materials are ideal because they are clean, odorless, and tasteless. They polymerize quickly and, especially when used with a custom tray, the amount of bulk of material can be kept to a minimum.

Several techniques have been suggested to improve the accuracy of polyvinyl siloxane impressions. Most commonly used are putty wash impression technique, putty wash one-step technique, and putty wash two-step technique. Polyethylene sheets are used as a spacer in the two-step putty wash impression technique[12], with these different techniques only the light body material should cover the entire preparation, but this cannot always be accomplished clinically. Researchers are of the opinion that the precision of the impression can be controlled by the impression method than the material itself. The study reinforces the opinion of the researchers that the accuracy of dies varied significantly between different impression methods[13].

This study was undertaken toevaluate the dimensional accuracy of the three representative Polyvinyl Siloxane (PVS) impression materials and to compare the accuracy of single mix with double mix impression technique. The three different materials used for the study were Aquasil, Flexceed and Imprint II Garant.

Standardized Stainless steel die similar to that described in ADA Specification no. 19 scored with three vertical and two horizontal lines was used for making impression. Stainless steel die was used because it does not absorb water, does not expand or shrink under variable temperatures and does not react with the impression material being used.

Total 60 samples were made which were divided into 3 groups (Group 1, Group 2 and Group 3) of 20 samples each. These 20 samples of each group were further divided into two subgroups of 10 specimens each (Group 1A, Group 1B, Group 2A, Group 2B, Group 3A, Group 3B). After 24h the dimensional accuracy was tested by using Profile Projector. After the readings were obtained, data was summarized in the tabulated form and subjected to analyze by ONE-WAY ANOVA and STUDENT′S NEWMAN-KEUL′S TEST.

TUKEY′S post hoc analysis reported that the mean difference for group 1B, group 2B, group 3B (0.182, 0.24, 0.16) were observed to be greater than group 1A, group 2A and group 3A (0.172, 0.231

and 0.151) respectively indicating that single mix impression technique showed more difference from the stainless steel die for all the materials as compared to double mix impression technique. These results indicate that double mix impression technique appears more dimensionally accurate than single mix impression technique for all the three different materials tested in this study.

Results of this study was in accordance with those of **Dhiman et al 2001**who compared the accuracy of reproduction of addition silicone impression material (Reprosil) with putty/wash one-step and two-step techniques indicating that two-step impression technique produced more accurate casts with less standard deviation.In the double-mix technique, the wash stage is carried out after the heavy body has set and contracted, and served as a custom tray. The controlled wash bulk compensates for this contraction with minimal dimensional changes. There is also a tendency for bubbles to form in the set impression which occurs more in single-mix impression technique than in double-mix impression technique.

A Study done by **Hung et al[14].**used a variety of addition-type silicone impression materials to investigate the effects of technique and choice of material on accuracy and concluded that the choice of the material is more important for the accuracy.

On the other hand**, Craig[15]**stated that the choice of technique was the more critical factor.

Nissan et al[12] compared the one-step and two-step impression techniques, with the polyethylene spacer and found no difference in the two techniques**. Idris et al[16]**also did the same study using a different method to create wash space and their conclusion was also same as **Hung *et al***.This may be attributed to the fact that, the critical factor that influences the accuracy is the wash bulk, where it is difficult to control wash bulk with the polyethylene spacer.

In another study the dimensional accuracy of monophase, one-step and two-step putty/light-body, and a novel two-step injection impression technique using silicone impression materials was compared and it was concluded that two-step putty/ light-body and two-step injection techniques were the most dimensionally accurate impression methods in terms of resultant casts[13].

Impressions were made using an auto mixing impression gun to obtain a homogeneous mixture. An intraoral tip was attached to the mixing tip to line the impression surface of the die with the impression material. Both the components of the impression material were pushed in a zigzag manner along the length of the mixing tip and syringed over the test surface of the die. The mold was filled completely with the impression material to ensure a uniform thickness of three mm. A thin polyethylene sheet (DPI, India) was then placed over the mold followed by a rigid flat metal plate. Sufficient force of 1000 g was applied to seat the plate firmly against the mould to permit extrusion of excess material. Once the impression was set, the mould and test block were separated. The impression was gently pressed out of the mould using the riser. The final test sample is obtained [Figure 2]. In this manner, a total of seventy five PVS test samples were made and these were stored in an airtight, clean polypropylene container (Parsons Pvt Ltd., Mumbai, Maharashtra, India.

Other studies which contradict the findings of the present study conducted by **Hassan**[17] to measure the dimensional changes in three silicone impression materials (Xantopren-H, President and Fulldent) using single mix and double mix techniques and concluded that Xantopren-H had more accurate dimensions and single mix gave more accurate casts. In other study conducted by**Lepeet al**[18]**.**the accuracy of a one-step versus two-step putty wash impression technique using five addition silicone impression materials was compared and it was found that the one-step impression technique was more accurate than the two-step impression technique.

The present study is in accordance with the study carried out by **Caputi and Varvara**[13], to compare the dimensional accuracy of a monophase, one-step and two-step putty/light-body, and a novel two-step injection impression technique using silicone impression materials in which it was concluded that two-step putty/light-body and two-step injection techniques were the most dimensionally accurate impression methods in terms of resultant casts.

CONCLUSION:

From the results of the present study, following conclusions have been drawn:

1. The accuracy of the polyvinyl siloxane impression materials tested was affected more by the material than by the technique.
2. When the dimensional accuracy of all the three impression materials in double mix and single mix impression technique were compared Imprint II Garant shows the least dimensional changes from the master die followed by Aquasil and Flexceed respectively.
3. Among the impression techniques, the double mix impression technique was more accurate than single mix impression technique.

   The results of the present study showed that in both double mix and single mix impression techniques, the least dimensional change was exhibited by Imprint II Garant followed by Aquasil and Flexceed. Hence, Imprint II Garant is the material of choice and double mix impression technique is the better technique.

LIMITATIONS:

There were possible limitations to this study. Since the present study was invitro, it was not possible to analyze the effect of such factors as blood, saliva, oral temperature, and special clinical conditions on the accuracy of impression techniques, which might have significant impacts on the obtained results e.g; high temperature in the oral cavity which is due to some hot foods may produce dimensional changes. Hence, future studies are recommended to examine this issue in clinical conditions and with different impression materials. Also other conditions were not examined which include rotational path of impression removal, the effects of gravity, different arch form of maxilla and mandible.

CLINICAL SIGNIFICANCE:

The results suggested that PVS hydrophilic materials with double mix impression technique lead to predictable success in the fixed prosthodontics and implantology procedures.

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