A Comparative Study to Evaluate the Accuracy of Various Spacer Thickness for Polyvinyl Siloxane Putty-wash Impression Techniques: An In Vitro Study

Nitin Gautam1, Rimsha Ahmed2, Sunny Sharma3, Praveen K Madineni4, Sarah Hasan5

Abstract

Introduction: An accurate impression is one of the prime factors for success of any restoration, more so in field of fixed prosthodontics. The critical aspect is to reproduce fine surface details along with ease of use. Knowledge of impression materials and the techniques to which each is best suited is essential in achieving consistent results.

Objective of the study: The purpose of this study is to evaluate the accuracy of various putty-wash techniques in a laboratory model that simulated the clinical practice.

Materials and methods: A metal master model, containing three full crowns fixed partial denture (FPD) abutment preparations, was fabricated. A perforated custom tray was fabricated that can be placed in the same position on the master model for each impression. For each technique, 10 impressions of the master model were made and poured using a die stone. The measurements were made of the models using a measuroscope and the accuracy of the impressions was recorded.

Results: The statistical comparison between groups I, II, III, and IV casts measurements by using the Mann–Whitney test showed highly significant statistical difference between the various groups from each other (p < 0.001)

Conclusion: The accuracy of the working casts obtained from group III impression (two-step using 1 mm coping) was the best, whereas it was least with group II impression (two-step using polyethylene spacer).

Keywords: Addition silicone, Impression, Impression technique, One-step technique, Spacer, Two-step technique.

Introduction

Dimensional accuracy of impression materials is an essential aspect for precision in fabrication of an indirect restoration. Preventing distortion during any step, from making impression to fabrication of the prosthesis, is practically unachievable. Consequently, the choice of the impression technique is an important factor that can affect the fit of the final restoration.1,2 As far as properties are concerned, polyvinyl siloxane (PVS) as compared to other impression materials has been reported to be more accurate and dimensionally stable.3–6 Accurate fit of the cast restorations is directly affected by the type of the impression technique used and a lot has been discussed in the literature about it. Some authors claim that the type of impression technique used plays a more important role in controlling the accuracy rather than the material,7 whereas others are of the view that the accuracy is not affected by the impression technique.8,9

To enhance the accuracy of polyvinyl siloxane, several techniques have been suggested. One-step technique, putty-wash two-step technique, and putty-wash two-step with polyethylene spacer are some of the common techniques used for making putty-wash impression.10,11 In addition, one of the crucial factors influencing the accuracy of impression materials is the thickness of the wash impression.12–14 So, the purpose of the study was to determine the accuracy of putty-wash impression techniques using various spacer thicknesses.

Materials and Methods

Preparation of Master Model

For this study, three fixed partial denture (FPD) abutment preparations with an occlusal taper of 6° were fabricated on a
metal master model (Fig. 1). The metallic model had a horizontal platform with a height of 6 mm in which a groove of 3-mm depth was made for the orientation of the metallic tray during the impression making. Two perpendicular cross grooves were engraved on the occlusal surface, which serve as reference points for taking the measurement. Two marks L (left) and R (right) were made on the horizontal platform to denote the number of the abutment preparation. Metal copings of 1-mm and 2-mm thickness throughout were fabricated to fit precisely all the three abutment preparations. A rigid metallic perforated tray was fabricated to prevent the rotation of the tray.

The impressions were grouped as:

- Group I: Impression materials for putty and wash impression were used simultaneously (single-step technique).
- Group II: A polyethylene spacer was used to create space for wash impression in putty material (two-step technique).
- Group III: 1-mm coping was used with the putty material to create an even space followed by the wash stage (two-step technique).
- Group IV: 2-mm coping was used with the putty material to create an even space followed by the wash stage (two-step technique).

Before the impressions were made, tray adhesive (3M) was applied onto the internal surface of the tray, and it was air-dried for 5 minutes.

For single-step impressions, an equal quantity of catalyst and base (3M express) of putty consistency was mixed thoroughly with hands and placed on to the perforated tray. The tray with the putty material was loaded on the impression tray and simultaneously the light body (3M express) with the help of an automatic mixing syringe with an attached tip was injected over the abutments (Fig. 2).

For a two-step technique with polyethylene spacer, impression was made in the putty material with the polyethylene sheet on the master model (Fig. 1). Once the impression was set, the final (light body) impression material was injected over the abutments, after which the spacer was removed and the tray was positioned back on the master model (Fig. 3).

For a two-step technique with 1-mm and 2-mm metal spacer, the whole procedure is repeated with a 1-mm and 2-mm metal copings used as a spacer (Figs 4 and 5). The light body material occupied the space all around created by removing the copings.

**Preparation of the Master Cast**

Before pouring the master cast, the impressions were kept for 30 minutes at the room temperature, followed by spraying with debubblizer (Dentfills, India) and blow dried. Mechanical mixing of improved dental stone under vacuum was done for 30 seconds and allowed to complete setting for 1 hour. Ten such impressions were made for each group and pouring of the casts was done to get master models (Fig. 6).

**Measurements**

A measuroscope (Fig. 7) was used for making the measurements of the master model along with groups I, II, III, and IV casts capable of measuring up to 0.001 mm. The inter-abutment distance was measured from the center of one cross-groove to another and the distance between the left and center die was designated as...
inter-abutment distance 1-2 and between center and right die was designated as inter-abutment distance 2-3. The mean value was computed after recording all the measurements three times by the same operator. The measurements of the master model and the stone casts obtained with all the four techniques were tabulated and statistically analyzed (Figs 8 to 11).

**Results**

After calculating the mean, tabulation and statistical analysis were carried out. For each group, and to calculate the differences between the groups, a descriptive statistical analysis like standard deviation and mean was calculated. The one-way analysis of variance (ANOVA) was used for multiple group comparison followed by the Mann-Whitney test for pairwise comparisons. A p value of less than 0.05 was considered for significance.

For inter-abutment distance 1-2, it was noted that the mean difference between master model and group I casts was 0.055 mm (expansion). In between master model and group II casts, the mean difference noted was −0.123 mm (contraction) whereas the mean difference noted between master model and group III casts was 0.022 mm (expansion). In between master model and group IV casts, the mean difference noted was 0.035 mm (expansion). Statistical comparison between groups I, II, III, and IV casts measurements by using the Mann-Whitney test showed highly significant statistical difference between the various groups from each other (p < 0.001) (Table 1).

For inter-abutment distance 2-3, it was observed that the mean difference between master model and group I casts was 0.062 mm (expansion). In between master model and group II casts, the mean difference observed was −0.098 mm (contraction) whereas the mean difference observed between master model and group III casts was 0.031 mm (expansion). In between master
A Comparative Study to Evaluate the Accuracy of Various Spacer Thickness for PVS Putty-wash Impression Techniques

model and group IV casts, the mean difference observed was 0.041 mm (expansion). Statistical comparison between groups I, II, III, and IV casts measurements by using the Mann–Whitney test showed highly significant statistical difference between the various groups from each other ($p < 0.001$).

**Discussion**

Making a precise replica of dental and dentoalveolar structures is one of the most important steps in fabrication of a fixed dental prosthesis. Tremendous progress has been made as far as various procedures for making fixed prosthodontic impressions are concerned.

The conventional hydrocolloid impression materials were replaced by rubber base impression materials due to various reasons. An amalgamation of dimensional stability, excellent physical properties, and ease of manipulation of polyvinyl siloxane (PVS) impression materials have made it extremely popular in recent past.6,15–19 As far as impression techniques are concerned, the putty-wash impression technique has gained wide popularity because of its ease of use20 and better time management due to no special need of a custom tray,11 thus saving a lot of clinical and laboratory time.

Also, in PVC impression materials, the stress that can lead to separation of the materials at their juncture is less than bond strength of the putty and wash material. Hence, potential errors in the impression are minimized.21 This can be attributed to the chemical nature of the bond between the putty material and the light body; and any cohesive failure that occurs is due to bond failure in the weaker material.22 Uniformity of the wash space is one more factor that has to be considered for accurate impression. Some authors5,12,23 reported that increasing the thickness of the wash material from 2 to 4 mm and 6 mm reduces the accuracy of impression because of its ease of use20 and better time management due to no special need of a custom tray,11 thus saving a lot of clinical and laboratory time.

Also, in PVC impression materials, the stress that can lead to separation of the materials at their juncture is less than bond strength of the putty and wash material. Hence, potential errors in the impression are minimized.21 This can be attributed to the chemical nature of the bond between the putty material and the light body; and any cohesive failure that occurs is due to bond failure in the weaker material.22 Uniformity of the wash space is one more factor that has to be considered for accurate impression. Some authors5,12,23 reported that increasing the thickness of the wash material from 2 to 4 mm and 6 mm reduces the accuracy of impression because of increased polymerization shrinkage. More distortion has been observed with the increased thickness of the wash material because of greater polymerization shrinkage.24,25

Certain factors such as tray,26 tray adhesive,27 and the impression technique may affect the accuracy of reproduction of an impression material. According to some authors like Bomberg et al.27 and Wassel et al.,7 the one-step technique produced more...
accurate casts; whereas Chee et al., Dhiman et al., Johnson et al., and Nissan et al. reported that the two-step technique was found to be more dimensionally accurate than the one-step technique. Still, some did not find any difference between the two.

The aim of this in vitro study was to compare the accuracy of stone casts obtained from one-step and two-step putty-wash techniques and to evaluate the accuracy of putty-wash impression techniques using various spacer thicknesses by measuring the stone casts. A perforated metallic tray with tray adhesive was used for making the impression. Base and catalyst consistencies of putty material were mixed with hands in equal quantity; and the gloves were avoided to prevent inhibition of polymerization. After removing the master model from the water bath, it was dried in the air. This helps in detailed reproduction of elastomeric impression materials that can be otherwise affected by the moisture on the master model. In the two-step technique, once the putty impression was made, it acted as a custom-made tray on which light body was added for the final reproduction of the surface details. For adding the light body on the abutment preparations, an automatic mixing system was used due to its simplicity and more precise impressions due to reduced bubbles. Impressions were sprayed with a debubblizer to reduce the surface tension of the impression material, thus resulting in void-free casts.

The results showed that for group I casts, the mean difference from master model for inter-abutment distance 1-2 was 0.055 mm (Table 2) and for inter-abutment distance 2-3 was 0.062 mm (Table 3). So this group showed an increase in inter-abutment distance, which could be attributed to the polymerization shrinkage of the material toward the adhesive-coated tray wall and because of setting expansion of die stone. These results are in agreement with the finding of Idris et al. and Nissan et al. who showed an increase in inter-abutment distance when the one-step putty-wash technique was used. This may result in dies that are long mesiodistally.

For group II casts, the mean difference from the master model for inter-abutment distance 1-2 was –0.123 mm (Table 2) and for inter-abutment distance 2-3 was –0.098 mm (Table 3), which showed a decrease in inter-abutment distance that is in agreement with the findings of Nissan et al. This can be attributed to the fact that in the two-step technique using polyethylene spacer, the wash bulk is not controlled. This allows for differential contraction and results in uneven dimensional change, which in turn may result in dies that are short mesiodistally.

For group III casts, the mean difference from the master model for inter-abutment distance 1-2 was 0.022 mm (Table 2) and for inter-abutment distance 2-3 was 0.031 mm (Table 3). So, the group III casts showed an increase in inter-abutment distance, which may have occurred because of contraction of the impression material toward the tray walls. This may result in dies that are long mesiodistally.

For group IV casts, the mean difference from the master model for inter-abutment distance 1-2 was 0.035 mm (Table 2) and for inter-abutment distance 2-3 was 0.041 mm (Table 3). So, the group IV casts showed an increase in inter-abutment distance, which may have occurred because of contraction of the impression material toward the tray wall, which is in agreement with the findings of Nissan et al. This may result in dies that are long mesiodistally.

It was also seen that the accuracy of the group III and group IV casts were within the accepted range (50 μm). However, group
Ill casts were more close to the master model than group IV casts in accuracy because increasing the thickness of wash materials increases the distortion of the impression because of greater polymerization shrinkage. Moreover, the accuracy of the two-step technique using uniform wash space was more than the one-step technique. Another disadvantage of the one-step impression is that the margins may be recorded in putty rather than light body because of the lower viscosity of the latter, which can result in inaccurate dies.

After tabulating the results, it was concluded that group III impression (two-step using 1-mm coping) produced the most accurate casts. Group IV impression (two-step using 2-mm spacer) produced more accurate casts than group I and group II impressions. The results coincided with the findings of Nissan et al. 1

Most dimensional discrepancies were shown in group I impression (one-step) and group II impression (two-step using polyethylene spacer), which has also been proven by Nissan et al. in their study. 1

The two-step technique with 1-mm/2-mm spacer thickness was proven by Nissan et al. in their study. 1

The dimensional discrepancies of category I, II, III, and IV casts were significantly different from each other. But, the replicability of group III and group IV casts was within the accepted clinical range.

**References**

1. Nissan J, Laufer BZ, Brosh T, et al. Accuracy of three polyvinyl siloxane putty-wash impression technique. J Prosthet Dent 2000;83(1):161–165. DOI: 10.1016/S0022-3913(00)80007-4.

2. Petersen GF, Asmussen E. Distortion of impression material used in the double mix techniques. Scand J Dent Res 1991;99(4):343–348. DOI: 10.1111/j.1600-0722.1991.tb01039.x.

3. Lacy AM, Fukui H, Bellman T, et al. Time-dependent accuracy of elastomer impression materials. Part II: polyether, polysulfide and polyvinylsiloxane. J Prosthet Dent 1981;45(3):329–333. DOI: 10.1016/0022-3913(81)90400-5.

4. Tjan AHL, Nemetz H, Nguyen LTP, et al. Effect of tray space on the accuracy of monophase polyvinyl siloxane impression. J Prosthet Dent 1992;68(1):19–28. DOI: 10.1016/0022-3913(92)90278-I.

5. Wassel RW, Ibbetson RJ. The accuracy of polyvinyl siloxane impression made with standard and reinforced stock trays. J Prosthet Dent 1991;65(6):748–757. DOI: 10.1016/S0022-3913(05)80006-X.

6. Yeh CL, Powers JM, Craig RG. Properties of addition type silicone impression materials. JADA 1980;101(3):482–484. DOI: 10.14219/jada.archive.1980.0321.

7. Chee WWL, Donovan TE. Polyvinyl siloxane impression materials. A review of properties and techniques. J Prosthet Dent 1992;68(5):728–732. DOI: 10.1016/0022-3913(92)90192-D.

8. Hung SH, Purk JH, Tira DE, et al. Accuracy of one step versus two step putty wash addition silicone impression technique. J Prosthet Dent 1992;67(5):583–589. DOI: 10.1016/0022-3913(92)90151-Y.

9. Idris B, Houston F, Claffey N. Comparison of the dimensional accuracy of one and two step techniques with the use of putty/wash addition silicone impression materials. J Prosthet Dent 1995;73(5):535–541. DOI: 10.1016/0022-3913(95)90358-0.

10. Johnson GH, Craig RG. Accuracy of addition silicons as a function of technique. J Prosthet Dent 1986;55(2):197–203. DOI: 10.1016/0022-3913(86)90342-2.

**Table 2:** Mean and percentage (%) of deviation from master model (MM) between various groups for inter-abutment distance 1-2

| Group        | Distance (in mm) | Deviation from MM | % deviation |
|--------------|------------------|-------------------|-------------|
| Category I   | 16.826           | 0.004             | 0.055 ± 0.004 | 0.33 ± 0.004 | 55 ± 0.007 |
| Category II  | 16.648           | 0.007             | 0.123 ± 0.007 | 0.74 ± 0.007 | 123 ± 0.007 |
| Category III | 16.793           | 0.004             | 0.022 ± 0.004 | 0.13 ± 0.004 | 22 ± 0.004 |
| Category IV  | 16.807           | 0.007             | 0.035 ± 0.007 | 0.21 ± 0.007 | 35 ± 0.007 |

**Table 3:** Mean and percentage (%) of deviation from master model (MM) between various groups for inter-abutment distance 2-3

| Group        | Distance (in mm) | Deviation from MM | % deviation |
|--------------|------------------|-------------------|-------------|
| Category I   | 16.490           | 0.005             | 0.062 ± 0.005 | 0.38 ± 0.005 | 62 ± 0.005 |
| Category II  | 16.330           | 0.007             | 0.098 ± 0.007 | 0.60 ± 0.007 | 98 ± 0.007 |
| Category III | 16.459           | 0.004             | 0.031 ± 0.004 | 0.19 ± 0.004 | 31 ± 0.004 |
| Category IV  | 16.469           | 0.005             | 0.041 ± 0.005 | 0.25 ± 0.005 | 41 ± 0.005 |

**Conclusion**

Within the limits of this study, the following inferences were drawn:

- The results showed that the two-step technique using uniform wash space produced more accurate casts than the one-step technique. Hence, the two-step technique using 1-mm and 2-mm coping is recommended for making the impressions of fixed partial denture prosthesis.

- The accuracy of the working casts obtained from group III impression (using 1-mm coping) was the best, followed by group IV impression (using 2-mm coping), group I impression (one-step) and the least with group II impression (two-step using polyethylene spacer).

- The dimensional discrepancies of category I, II, III, and IV casts were significantly different from each other. But, the replicability of group III and group IV casts was within the accepted clinical range.
A Comparative Study to Evaluate the Accuracy of Various Spacer Thickness for PVS Putty-wash Impression Techniques

11. Saunders WP, Sharkey SW, Smith G, et al. Effect of impression tray design and impression technique upon the accuracy of stone casts produced from a putty-wash polyvinyl siloxane impression material. J Dent 1991;19(5):283–289. DOI: 10.1016/0300-5712(91)90072-2.

12. Eames WB, Sieweke JC, Wallace SW, et al. Elastomeric impression materials: effect of bulk on accuracy. J Prosthet Dent 1979;41(3):304–307. DOI: 10.1016/0022-3913(79)90013-1.

13. Takashi H, Finger WJ. Effects of the setting stage on the accuracy of double mix impression made with addition curing silicone. J Prosthet Dent 1994;72(1):78–84. DOI: 10.1016/0022-3913(94)90215-1.

14. Williams PT, Jackson DG, Bergmen W. An evaluation of the time dependent dimensional stability of eleven elastomeric impression materials. J Prosthet Dent 1984;52(1):120–125. DOI: 10.1016/0022-3913(84)90194-X.

15. David B. An update on elastomeric impression materials. Br Dent J 1981;150:35–40.

16. Craig RG, Urquiola NJ, Liu CC. Comparison of commercial elastomeric impression materials. Oper Dent 1990;15:94–104.

17. Dounis GS, Ziebert GJ, Dounis KS. A comparison of impression materials for complete – arch fixed partial denture. J Prosthet Dent 1991;65(2):165–169. DOI: 10.1016/0022-3913(91)90157-R.

18. Thongthammachat S, Moog K, Barco MT, et al. Dimensional accuracy of dental casts: influence of tray material, impression material, and time. J Prosthet Dent 2002;112(2):98–108. DOI: 10.1053/jopr.2002.125192.

19. Tjan AHL, Whang SB, Tjan AH, et al. Clinically oriented evaluation of the accuracy of commonly used impression material. J Prosthet Dent 1986;56(1):4–8. DOI: 10.1016/0022-3913(86)90272-6.

20. Chee WWL, Donovan TE. Fine detail reproduction of very high viscosity poly (vinyl siloxane) impression materials. Int J Prosthodont 1989;2(4):368–370.

21. Sandrik JL, Vacco JL. Tensile and bond strength of putty-wash elastomeric impression materials. J Prosthet Dent 1983;50(3):358–361. DOI: 10.1016/0022-3913(83)80092-4.

22. Cullen DR, Sandrik JL. Tensile strength of elastomeric impression materials, adhesive and cohesive bonding. J Prosthet Dent 1989;62(2):142–145. DOI: 10.1016/0022-3913(89)90300-4.

23. Fairhurst CW, Furman TC, Schallhorn RV, et al. Elastic properties of rubber base impression materials. J Prosthet Dent 1956;6(4):534–542. DOI: 10.1016/0022-3913(56)90097-X.

24. Araujo PAD, Jorgensen KD. Effect of material bulk and undercuts on the accuracy of impression materials. J Prosthet Dent 1985;54(6):791–794. DOI: 10.1016/0022-3913(85)90472-X.

25. Araujo PAD, Jorgensen KD. Improved accuracy by reheating addition – reaction silicone impressions. J Prosthet Dent 1986;55(1):11–12. DOI: 10.1016/0022-3913(86)90061-2.

26. Gordon GE, Johnson GH, Drennon DG. The effect of tray selection on the accuracy of elastomeric impression materials. J Prosthet Dent 1990;63(1):12–15. DOI: 10.1016/0022-3913(90)90257-D.

27. Bomberg TJ, Goldfogel MH, Hoffman W, et al. Considerations for adhesion of impression materials to impression trays. J Prosthet Dent 1988;60(6):681–684. DOI: 10.1016/0022-3913(88)90398-8.

28. Dhimar RK, Agarwal SK, Dhir RC. Dimensional accuracy of putty/ wash one step and two step techniques using polyvinyl siloxane impression material: in vitro study. The J Ind Prosthodont Soc 2001;1(2):36–43.

29. Johnson GH, Drennon DG. Clinical evaluation of detail reproduction of elastomeric impression materials. J Dent Res 1987;66(1_suppl):331. DOI: 10.1777/002203458706605108.

30. Stackhouse JA. The accuracy of stone dies made from rubber impression material. J Prosthet Dent 1970;24(4):377–386. DOI: 10.1016/0022-3913(70)90078-8.

31. Anusavice KJ. “Phillips’ Science of Dental Materials. 11th ed., 2003. pp. 214–225.

32. Reitz CD, Clark NP. The setting of vinyl polysiloxane and condensation silicone putties when mixed with gloved hands. JADA 1988;116(3):371–379. DOI: 10.14219/jada.archive.1988.0236.

33. Johnson GH, Lepe L, Av W. The effect of surface moisture on detail reproduction of elastomeric impression. J Prosthet Dent 2003;90(4):354–364. DOI: 10.1016/S0022-3913(03)00429-3.

34. Chong YH, Soh G. Effectiveness of intraoral delivery tips in reducing voids in elastomeric impressions. Quint Int 1991;22(11):901–910.

35. Craig RG. Evaluation of an automatic mixing system for an addition silicone impression material. JADA 1983;110(2):213–215. DOI: 10.14219/jada.archive.1985.0248.

36. Lim KC, Chong YH, Soh G. Effect of operator variability on void formation in impressions made with an automixed addition silicone. Aust Dent J 1992;37(1):35–38. DOI: 10.1111/j.1834-7819.1992.tb00831.x.

37. Soh G, Chong YH. Defects in automixed addition silicone elastomers prepared by putty-wash impression technique. J Oral Rehabil 1991;18(6):547–553. DOI: 10.1111/j.1365-2842.1991.tb00077.x.

38. Millar BJ, Dunne SM, Robinson PB. The effect of a surface wetting agent on void formation in impressions. J Prosthet Dent 1997;77(1):54–56. DOI: 10.1016/S0022-3913(97)70207-5.

39. Panitchatra R, Jones RM, Goodacre C, et al. Hydrophilic poly(vinyl siloxane) impression materials. Dimensional accuracy, wettability, and effect on gypsum hardness. Int J Prosthodont 1991;4(3):240–248.

40. Marshak B, DAssif R. Pilo: a controlled putty-wash impression technique. J Prosthet Dent 1990;64(6):635–656. DOI: 10.1016/0022-3913(90)90285-K.

41. Messias AM, Silva SCR, Abi-Rached FO, et al. Effect of techniques, trays and materials on accuracy of impressions. Rev Odontol Unesp 2019;48:1–10. DOI: 10.1590/1807-2577/06419.