

Dimensional Accuracy of Resultant Models Made of Polyvinyl Siloxane and Polyther Impression Material using Different Impression Techniques: An *In Vitro* Comparison Study

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ABSTRACT

Background: The success of any dental prosthesis largely depends upon the accuracy and dimensional stability of the impression materials and the impression techniques used. The choice of impression material is equally vital in achieving accurate impression. The aim of the present study was to find out which impression material and technique could give the best dimensional accuracy.

Material & Methods: An in vitro study was done in the Department of Prosthodontics, JNIMS Dental College, Imphal. Forty impressions were made using silicon and polyether impression material of the master model, 10 each by using the four different techniques viz. one-step putty wash technique using addition silicone, two-step putty wash technique using addition silicone, matrix impression technique using polyether and by dual arch impression technique using addition silicone. These impressions were poured at different intervals, i.e. at 0 h, 1 h and 24 h. Thus, total of thirty models from each impression technique were poured to get the study samples. The proportioning of the impression materials and mixing process were done as per the manufacturers' instructions. And the impressions were grouped into four groups depending upon the technique used. Five different dimensions (for measuring crown height and diameter and inter-abutment space) were measured on the master model (control) and on the stone models obtained from each of the impression technique. This data was statistically analysed and compared.

Results: Within the four groups of impressions, there was significant difference in all the mean dimensions. There was an average decrease in the height and the width of the crowns. Also, the abutment distance increased for almost all the resultant dies.

Conclusion: The putty wash technique and matrix impression technique were found to be more dimensionally stable than single-mix technique and dual arch impression technique.

Keywords: Dental impressions, Dimensional accuracy, Impression materials, Polyvinyl siloxane

ABBREVIATIONS

VPS: Vinyl poly siloxane; SD: Standard deviation; T-test: Student's t-test; ANOVA: Analysis of variance

INTRODUCTION

A dental impression is a facsimile of oral tissues, recorded with an impression material at unstrained resting position or in various degrees of displacement. The success of dental prosthesis largely depends upon the accuracy and dimensional stability of the impression materials used and the impression techniques employed [1,2]. Dimensional accuracy is crucial for the quality and success of fixed prosthodontic treatment. But it has been reported that over 89% of impressions investigated had one or more observable

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errors [3]. Thus, there is a need for more critical evaluation of the impression on the part of the dentists.

The choice of impression material is also equally vital in achieving accurate impressions. Many impression materials have been in vogue. Yet, they had their own limitations. Agar-agar was at one time the most commonly used material, but it had poor tear resistance and needed elaborate equipment while making the impressions. Alginate was also tried but it was highly technique-sensitive and had poor surface detail reproduction and dimensional stability. While polysulfides provided good quality reproduction; but they had an unpleasant taste and odor as well as take a long time for setting. They also exhibit poor dimensional stability since they yield water as a by-product [4]. Condensation silicone impression materials have also been used but they also showed dimensional instability because of the production of an alcohol by-product during polymerization [5]. Addition silicones were also in vogue in 1980s with good results [6].

More recently, Vinyl Siloxanether has been made available in the market with claims of possessing good flow properties along with excellent wetting characteristics when applied to the prepared tooth and good mechanical properties after setting. But its accuracy is yet to be established [7]. Further, techniques that use monophase materials are executed as a single step technique; these techniques use the materials with a medium viscosity to allow the material itself to record the finer details. Other techniques that use dual phase materials such as putty and light body wash may be accomplished in one or two steps. The one-step putty/light body technique requires less chair-time. In the two-step technique, the details are recorded by the light body material only [8]. Thus, clinicians have an excellent array of impression materials and techniques to use in the fabrication of tooth or implant-supported fixed restorations.

The main aim of the present study was to compare the dimensional accuracy of polyvinyl siloxane impression

material used with four different impression techniques viz. one-step putty technique, two-step putty technique, matrix impression technique and dual arch impression technique.

MATERIAL & METHODS

An *in vitro* study was done in the Department of Prosthodontics, Dental College, Jawahar Lal Nehru Institute of Medical Sciences (JNIMS), Imphal, India. The materials used for sample preparations were Photosil (light body), Photosil (putty), Monophase and VPS tray adhesive to make impressions. Exabite II NDS (light body) was used to make matrix and Kalrock dental stone was used to make the sample models. Typhodont (Trudent) was used as a master model and stainless-steel impression trays were utilized for making the impressions. Pentamix (3M ESPE) was used for mixing impression material, vacuum mixer (Multivac-4, Germany) was utilized for mixing investment material and Vernier calliper (Aerospace Ltd) was used for taking measurements.

A typhodont model was taken and the right mandibular first molar tooth was removed from it to simulate a clinical case of three Unit Bridge. Mandibular second premolar and second molar were prepared as abutments with a shoulder finish line having a width of 1.2 mm. The diamond points used were flat end tapered, small wheel, long needle diamond, radial fissure burr and biangle chisel as used conventionally in similar studies [9]. Three sharply defined notches were placed with round diamond on each prepared tooth as reference points; the reference points are shown in **Figures 1** and **2**. Reference point ‘a’ was placed on buccal finish line of right mandibular molar; point ‘b’ was made at the centre of occlusal surface of right mandibular molar (**Figure 1**); point ‘c’ was placed on lingual finish line of right mandibular molar (**Figure 2**); point ‘d’ was made on buccal finish line of right mandibular 2nd premolar; point ‘e’ was placed at centre of occlusal surface of right mandibular premolar (**Figure 1**) and point ‘f’ was made on lingual finish line of right mandibular premolar (**Figure 2**).

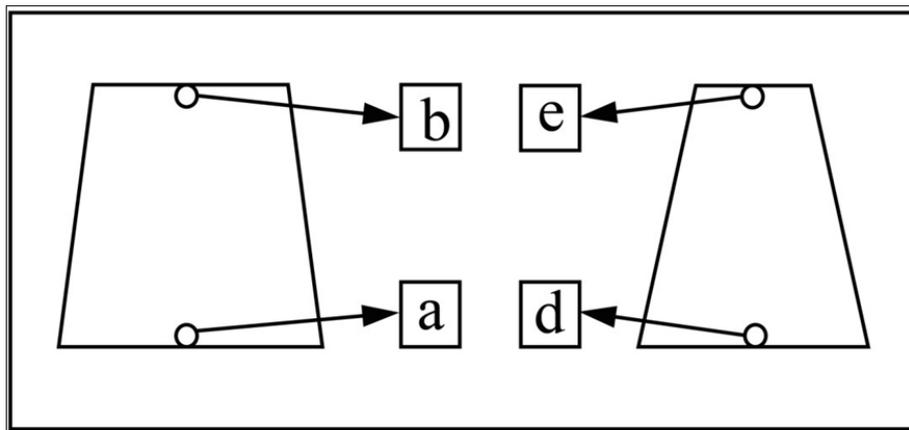


Figure 1. Diagrammatic representation of Buccal view of right mandibular 2nd premolar and right 2nd molar showing reference points.

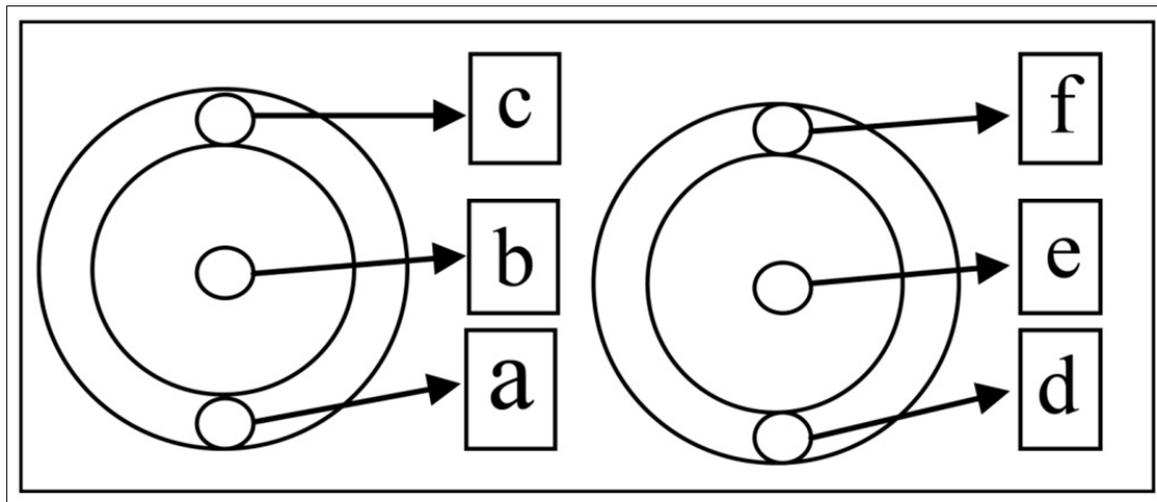


Figure 2. Diagrammatic representation of Occlusion view of right mandibular 2nd premolar and right 2nd molar showing reference points.

(a: Point made on the buccal finish line of right mandibular molar; b: Point made at the centre of occlusal surface of right mandubular molar; c: Point placed on the lingual finish line of right mandubular molar; d: Point made on the buccal finish line of right mandibular 2nd premolar; e: Point placed at the centre of occlusal surface of right mandibular premolar and f: Point placed on the lingual finish line of right mandibular premolar)

The occluso-cervical dimension (vertical height) of right mandibular 2nd molar and 2nd premolar (a-b and d-e respectively), bucco-lingual dimension (width at finish line) of right mandibular 2nd molar and 2nd premolar (a-c and d-f respectively) and inter-abutment distances between right mandibular 2nd molar and 2nd premolar (b-e) were measured and recorded. These measurements represent the basic dimensions of Master Model (control group).

DESCRIPTION

Forty impressions were made using silicon and polyether impression material of the master model, 10 each by using the four different techniques viz. one-step putty wash technique using addition silicone, two-step putty wash technique using addition silicone, matrix impression technique using polyether and by dual arch impression technique using addition silicone. These impressions were poured at different intervals, i.e. at 0 h, 1 h and 24 h. Thirty samples of impressions poured in this way, prepared by using the four different techniques, thus, became the study sample.

Impression procedure

Thirty impressions were made on Stainless steel custom-made perforated impression trays. A 5mm space was provided using biostar sheet and adapting it over the teeth of the master model. Three orientation stops were made on the buccal and labial aspects of typhodont and an extension was made with self-cure from the tray to the nick as to prevent any further displacement of it and also to ensure even flow of material. These impression materials were manipulated according to the manufacturers' instructions.

Impression making

The proportioning of the impression materials and mixing process were done as per the manufacturers' instructions. And, the impressions were grouped depending upon the technique used (Group A: one-step putty wash; Group B: two-step putty wash; Group C: matrix impressions and Group D: dual arch impression).

Removal of impression from the master die

After the impression material had set, the impression tray was gently pried away from the master model with the help of a blunt instrument ensuring that the vacuum between the master die and the impression was broken with ingress of air. The impression was then snapped off the master die in a quick vertical motion.

Preparation of dies

All the impressions were poured three times using Kalrock die stone maintaining water: powder ration of 23 mL: 100g. Three pours of each impression were done at different time intervals of 0 h, 1 h and 24 h.

Data collection and analysis

Five different dimensions (distances a-b, d-e, a-c, d-f and b-e) were measured on the master model (control) and on the stone models obtained from each of the impression technique. The mean values (SD) were calculated. The null hypothesis that no difference would exist in the dimensional accuracy of casts fabricated with the different impression materials was adopted. T-test was used to compare the control group values with the values obtained from all the

sample groups. The percent variation to each of the dimensions was found out by dividing the difference in value between stone die and master model by the corresponding dimension on master die. The percent variation was used to compare the dimensional accuracy of the four impression techniques. For each dimension, one-way analysis of variance was done to assess the significance of the differences in both the absolute dimensional measurements and their corresponding percent deviations from the stainless-steel model among the test groups. A p-value of <0.05 was considered to be significant.

RESULTS

The basic dimensions of the Master Model (control group) were recorded as a-b = 4.79mm, a-c = 5.95mm, d-e = 5.04mm, d-f = 4.87mm and b-e = 17.9mm. The comparisons of the control group standard values with values obtained from the different groups (A, B, C and D) showed that there was significant difference in the mean of distance (a-b) in Group A casts poured immediately, Group B casts poured

after 1 h and 24 h and in all Group C casts. Similarly, mean difference in distance (a-c) in all the group A casts poured at all the different intervals, in Group B casts poured at 1 h and in all the Group C and D casts poured at all the different intervals. The mean difference in distance (d-e) was also found to be significantly different from the control group in all Group A and C casts poured at the various intervals, Group B casts poured immediately, and Group D casts poured immediately and after 1 h. The mean difference in the distance (d-f) was found to be statistically different in Group A casts poured at all the different timings, Group B casts poured immediately and after 24 h, and Groups C and D casts poured at all the different test intervals. Lastly, the mean difference in the distance (b-e) was also found to be significantly different from the control values for Group A, B and C casts poured at the different timings and in Group D casts poured at 1 h and 24 h (Table 1). The other mean differences of casts poured at other intervals in other groups were not found to be significant.

Table 1. Comparison of control group standard values with values obtained from all the sample groups.

Dimension	Group	Cast poured (n=10 each)	Mean (SD)	t-value	Mean difference	P-value	
Distance (a-b)	A	Immediate	4.753 (±0.045)	0.527	0.137	<0.001	
		After 1 h	4.722 (±0.070)	0.084	0.068	0.013	
	B	After 24 h	4.675 (±0.064)	0.714	0.115	<0.001	
		C	Immediate	5.134 (±0.068)	0.993	0.344	<0.001
			After 1 h	5.083 (±0.087)	1.706	0.293	<0.001
			After 24 h	5.089 (±0.064)	1.809	0.299	<0.001
Distance (a-c)	A	Immediate	5.713 (±0.058)	1.979	0.237	<0.001	
		After 1 h	5.701 (±0.074)	1.705	0.249	<0.001	
		After 24 h	5.775 (±0.036)	1.381	0.175	<0.001	
	B	After 1 h	5.904 (±0.052)	0.803	0.046	0.021	
		C	Immediate	6.119 (±0.087)	1.162	0.169	<0.001
	After 1 h		6.119 (±0.071)	1.461	0.156	0.002	
	After 24 h		6.143 (±0.092)	1.650	0.193	<0.001	
	D	Immediate	6.051 (±0.643)	1.962	0.101	0.001	
		After 1 h	6.083 (±0.062)	1.042	0.138	<0.001	
		After 24 h	6.138 (±0.069)	1.565	0.188	<0.001	
	Distance (d-e)	A	Immediate	5.169 (±0.065)	0.238	0.129	<0.001
			After 1 h	5.282 (±0.032)	0.806	0.242	<0.001
After 24 h			5.150 (±0.055)	1.281	0.110	<0.001	

	B	Immediate	4.873 (±0.046)	1.491	0.167	<0.001
	C	Immediate	5.179 (±0.083)	1.309	0.139	<0.001
		After 1 h	5.209 (±0.073)	1.281	0.169	<0.001
		After 24 h	5.252 (±0.041)	1.228	0.212	<0.001
	D	Immediate	4.871 (±0.102)	-5.238	-0.169	0.001
		After 1 h	4.952 (±0.115)	-2.416	-0.088	0.039
Distance (d-f)	A	Immediate	5.174 (±0.604)	1.915	0.304	<0.001
		After 1 h	5.120 (±0.064)	1.297	0.250	<0.001
		After 24 h	5.180 (±0.054)	1.100	0.310	<0.001
	B	Immediate	5.062 (±0.042)	1.329	0.192	<0.001
		After 24 h	4.930 (±0.066)	1.890	0.060	0.018
	C	Immediate	5.030 (±0.044)	1.570	0.160	<0.001
		After 1 h	4.996 (±0.099)	1.038	0.126	0.003
		After 24 h	5.011 (±0.061)	1.353	0.141	<0.001
	D	Immediate	4.941 (±0.098)	1.298	0.071	0.047
		After 1 h	5.110 (±0.286)	1.654	0.240	0.026
		After 24 h	5.172 (±0.258)	1.698	0.302	0.005
	Distance (b-e)	A	Immediate	18.189 (±0.055)	1.720	0.289
After 1 h			18.176 (±0.103)	1.484	0.276	<0.001
After 24 h			18.384 (±0.292)	1.256	0.485	0.001
B		Immediate	18.056 (±0.122)	4.720	0.156	0.003
		After 1 h	18.008 (±0.057)	3.484	0.108	<0.001
		After 24 h	18.353 (±0.369)	5.256	0.453	0.004
C		Immediate	19.099 (±0.111)	1.680	0.199	<0.001
		After 1 h	18.104 (±0.047)	1.810	0.204	<0.001
		After 24 h	18.121 (±0.061)	1.491	0.221	<0.001
D		After 1 h	18.059 (±0.105)	1.768	0.159	0.001
		After 24 h	19.090 (±0.091)	1.582	0.190	<0.001

When inter-group analysis was done by using one-way ANOVA test for the mean dimensions (a-b, a-c, d-e, d-f and b-e) for the four sample group casts poured at the three different time-intervals, there was significant difference in all the measurements.

Thus, it can be inferred that there was an average decrease in the height of crowns (a-b and d-e). Also, it was seen that the width of the crowns (a-c and d-f) became larger in diameter in the resultant dies. Further the abutment distance (b-e) increased for almost all the resultant dies.

DISCUSSION

The average decrease in the crown-height as seen from the present study is comparable with study-findings made by Dabas and Stackhouse [2,10]. Dies might become shorter in dimension because the vertical component of contraction was towards the occlusal portion of preparation where the impression was adhering to the tray for elastometric impression material. Contrary to the present study finding, Gordon GE et al found an increase in height of the study

[11]. This might happen because of polymerization shrinkage of the materials which can lead to a larger die.

Earlier studies done by Kumar et al., Wassel et al. and Johnson et al. supports the present study finding that the resultant dies become larger in crown-width and resultantly in the diameter [12-14]. This finding can be due to the fact that the addition silicone impression material shows polymerization shrinkage towards the walls of the impression resulting in oversized die.

The increase in the abutment distance as found out from the present study is in accordance with earlier study findings made by other scholars [14,15]. This phenomenon can also be explained by the shrinkage of impression material towards the tray-walls where the adhesive is placed which causes a resultant increase in the inter-abutment space in the ensuing casts. Kumar V et al. in their study found slight increase in the height of the abutment [16]. This can be attributed to the polymerization shrinkage of the impression material towards the impression tray-walls because of the constraint induced on the impression material by an effective adhesive during setting of the impression material.

CONCLUSION

In spite of being an *in vitro* study and being not able to stimulate the actual clinical conditions where the impressions are made at mouth temperature of 37°C, important deduction can be made from the present study. In the current study, two factors were considered: One was the elapsed period of time and the other was the repeated distortion while withdrawing the multiple casts from the same impression.

The putty wash technique and matrix impression technique were found to be more dimensionally stable than single-mix technique and dual arch impression technique. The double arch impression technique resulted in casts that were least accurate but was clinically acceptable. The casts poured after one hour, were found to be most dimensionally stable. Clinicians when selecting impression technique may take note of the findings made in the present study.

All the impression materials and techniques were quite accurate in reproducing details for quite some time. The differences detected were small in magnitude and may be of minor clinical significance in the light of other important factors to be considered such as tooth mobility, mandibular deformation during opening, potential laboratory-related inaccuracies and clinically acceptable values for marginal gaps of crowns (100-150 µm).

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