Original Article

Evaluation of surface detail reproduction, dimensional stability and gypsum compatibility of monophase polyvinyl-siloxane and polyether elastomeric impression materials under dry and moist conditions

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Abstract

Objectives: This *in vitro* study was designed to compare polyvinyl-siloxane (PVS) monophase and polyether (PE) monophase materials under dry and moist conditions for properties such as surface detail reproduction, dimensional stability, and gypsum compatibility. **Materials and Methods:** Surface detail reproduction was evaluated using two criteria. Dimensional stability was evaluated according to American Dental Association (ADA) specification no. 19. Gypsum compatibility was assessed by two criteria. All the samples were evaluated, and the data obtained were analyzed by a two-way analysis of variance (ANOVA) and Pearson's Chi-square tests. **Results:** When surface detail reproduction was evaluated with modification of ADA specification no. 19, both the groups under the two conditions showed no significant difference statistically. When evaluated macroscopically both the groups showed statistically significant difference. Results for dimensional stability showed that the deviation from standard was significant among the two groups, where Aquasil group showed significantly more deviation compared to Impregum group ($P < 0.001$). Two conditions also showed significant difference, with moist conditions showing significantly more deviation compared to dry condition ($P < 0.001$). The results of gypsum compatibility when evaluated with modification of ADA specification no. 19 and by giving grades to the casts for both the groups and under two conditions showed no significant difference statistically. **Conclusion:** Regarding dimensional stability, both impregum and aquasil performed better in dry condition than in moist; impregum performed better than aquasil in both the conditions. When tested for surface detail reproduction according to ADA specification, under dry and moist conditions both of them performed almost equally. When tested according to macroscopic evaluation, impregum and aquasil performed significantly better in dry condition compared to moist condition. In dry condition, both the materials performed almost equally. In moist condition, aquasil performed significantly better than impregum. Regarding gypsum compatibility according to ADA specification, in dry condition both the materials performed almost equally, and in moist condition aquasil performed

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better than impregum. When tested by macroscopic evaluation, impregum performed better than aquasil in both the conditions.

Key words: *ADA specification no. 19, aquasil, dimensional stability, gypsum compatibility, impregum, monophase elastomers, polyvinyl siloxane, polyether, surface detail reproduction*

INTRODUCTION

Impression making is the primary step in the process of fabrication of an indirect prosthetic restoration. Precision of the impression material in terms of dimensional stability, surface detail reproduction, and compatibility with gypsum products is an essential prerequisite for a successful restoration. Elastomers are known for accuracy among the available impression materials.[1] Vinyl polysiloxane (VPS) and polyether (PE) are the most widely used elastomers and materials of choice for making fixed and removable prosthodontic impressions.[2-7]

Impression making techniques are of two types, namely, monophase and dual-phase techniques. Technique that uses monophase materials is a single-step procedure using a medium viscosity material to record the finer details with a custom tray. In the dual-phase technique, viscosities such as the putty and the light-body are used in 1 or 2 steps. In both the techniques, the finer details are recorded by the light-body material.[8] Many studies have been conducted regarding accurate reproduction of the details for VPS and PE under dry, moist, and wet conditions comparing monophase and dual phase impression techniques, under single step, two step, and two step with modifications. Final impressions made with custom tray using medium body materials proved to be precise than the rest of the techniques. However, there is limited data regarding evaluation of monophase materials exclusively.

The aim of the study is to analyze the effect of dry and moist conditions on the physical properties of hydrophilic monophase elastomeric impression materials.

MATERIALS AND METHODS

The apparatus to evaluate dimensional stability, surface detail reproduction, and gypsum compatibility of elastomeric impression materials according to American National Standards Institute (ANSI)/American Dental Association (ADA) specification no. 19 consists of four parts, namely, Ruled block (AA), Impression material mold (BB), Riser (CC), and Gypsum mold (DD) [Figure 1].[9] The ruled block on its impression making surface had three vertical lines namely x, y, and z, and two horizontal lines, namely, cd and c'd'. Riser was used in supporting and raising the impression to the edge of the impression material mold for ease of evaluation of impressions. The gypsum mold used to make the die stone cast has a 5° taper internally and a provision to fit the impression material mold with the riser along with impression in it. One such apparatus consisting of all four parts was used to make all the impressions and gypsum molds.

The mixed impression material was added to the impression material mold. For moist condition, the impression surface was once swiped with wet cotton gauze soaked with water. In both dry and wet conditions, the impression material mold was immediately covered with a thin sheet of polyethylene followed by a glass slab and metallic weight of 500 g. After 3 min, the impression material mold and ruled block were separated [Figure 2].

The sample size was 50 per group and was calculated using the results of previous studies.[1] A total of 200 impressions (2 × 2× 50) were made.

In this study, surface detail reproduction was evaluated with a modification of ANSI/ADA specification no. 19. Rather than only to evaluate the continuity of 1 of the 3 horizontal lines in 2 out of 3 specimens, all 3 lines were assessed for all the specimens. The

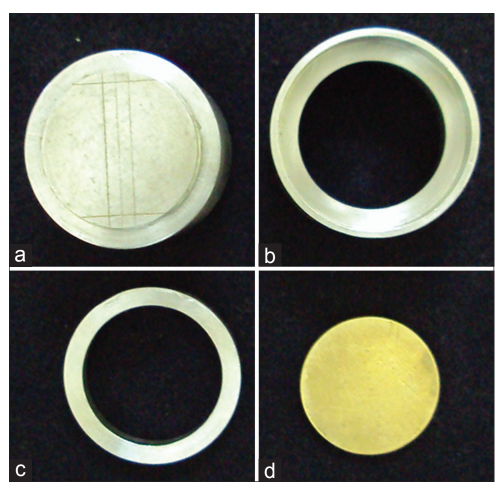

Figure 1: Apparatus prepared according to ANSI/ADA specification No.19. (a) Ruled block; (b) gypsum mold; (c) impression material mold; and (d) riser

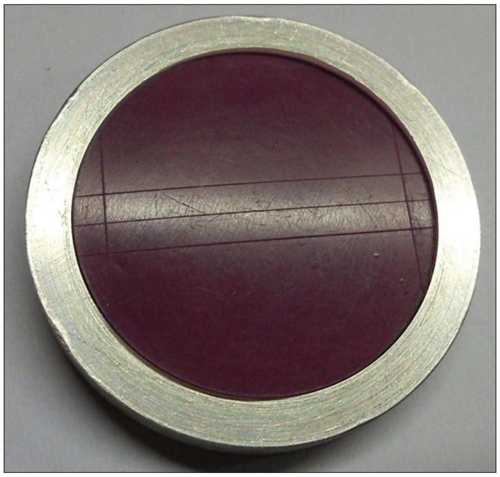

Figure 2: Impression made with monophase impression material

Figure 3: Type IV gypsum cast

impressions in which at least 2 of the 3 horizontal lines were reproduced continuously were considered satisfactory and the rest were considered unsatisfactory. This modification was made following guidelines from the previous studies to obtain the power analysis parameters and to maintain a manageable sample size.[2,6] For macroscopic evaluation, impressions were rated satisfactory if the entire impression surface was smooth, shiny, and free of voids or pits; and impressions were rated as unsatisfactory if the impression surface was rough or contained any pits or voids.[2,6] This macroscopic examination was done using a stereo zoom microscope (Olympus SZ61-TR, Italy) without any magnification under low-angle illumination.

The same impressions used to evaluate the surface detail reproduction were used to evaluate dimensional stability. The distance between the crosslines cd and c'd' on the ruled block was measured three times to the nearest 0.005 mm and the mean was recorded as reading A. Twenty-four hours after each impression was made, the same calculation was repeated and recorded as reading B for the same impression. Dimensional change was calculated as follows: % of dimensional change = (A − B)/A × 100.

The gypsum mold was fitted surrounding the impression material mold and lubricated with a mold release agent such as silicone high vacuum grease to facilitate the removal of the poured cast. After mixing the die stone for 1 min in a vacuum mixer, the mix was poured against the impression into the gypsum mold using high frequency vibration to get the least voids in the cast and to fill the gypsum mold with a uniform mix. Cast was removed from the gypsum mold after 30 min. Two hundred die stone casts were poured repeating the same procedure [Figure 3]. Each gypsum cast was separated from the gypsum mold and examined under low-angle illumination with up to 10 times magnification using a Stereo zoom microscope. All the casts were evaluated following the ANSI/ADA specification no. 19 with a modification as well as by macroscopic examination following the guidelines from the previous studies. ANSI/ADA specification no. 19 was modified by following guidelines from a previous study so that each cast was considered satisfactory only when the required 0.020 mm line was reproduced continuously for the full 25 mm between cross lines cd and c'd' in all the prepared specimens. The second criterion was to evaluate gypsum compatibility by giving grades to all the die stone casts prepared. A grade of 4 represents perfect reproducibility of the 0.020 mm line on the ruled block, which is a sharp V shape in cross-section; a grade of 3 represents a slight loss of clarity with the V shape becoming rounded; a grade of 2 represents that a part of the line was not reproduced; and a grade of 1 represents that the line was not reproduced at all. All the 200 samples were evaluated and the data obtained was analyzed by a two-way analysis of variance (ANOVA) and Pearson's Chi-square tests.

RESULTS

In the impregum group, under dry condition, surface detail reproduction according to ADA specification was satisfactory in 49 (98%) samples whereas it was satisfactory in 45 (90%) samples under moist condition. However, the difference between dry and moist conditions was not significant statistically (P = 0.092). All the samples of the aquasil group showed satisfactory surface detail reproduction irrespective of dry or moist condition [Table 1].

In the impregum group, under dry condition, surface detail reproduction according to macroscopic evaluation was satisfactory in 32 (64%) samples whereas it was satisfactory in only 8 (16%) samples under moist condition. The difference between dry and moist conditions was highly significant statistically ($P < 0.001$). In the aquasil group, 34 (68%) samples showed satisfactory surface detail reproduction under dry condition whereas 20 (40%) samples showed satisfactory surface detail reproduction under moist condition with statistically significant difference ($P = 0.005$) [Table 2].

Dimensional stability using linear dimensional change test

In the impregum group, under dry conditions, mean dimensions were 0.012 ± 0.483 units less than the standard, whereas under moist condition mean dimensions were 0.273 ± 0.281 units more than the standard. Overall, the impregum group showed that mean dimensions were 0.130 ± 0.418 units more than the standard. In the aquasil group, under dry conditions, mean dimensions were 0.458 ± 0.570 units more than the standard, and under moist condition these were 0.776 ± 0.738 units more than the standard. Overall, the aquasil group showed that mean dimensions were 0.617 ± 0.675 units more than standard. Overall, under dry condition, mean dimensions were 0.223 ± 0.576 units more than the standard, and under moist condition mean dimensions were 0.524 ± 0.610 units more than the standard. The results were statistically analyzed by two-way ANOVA and showed that the deviation from standard was significantly different among the two groups, where the aquasil group showed significantly more deviation compared to the impregum group ($P < 0.001$). Two conditions also showed significant difference, with moist conditions showing significantly more deviation compared to the dry condition ($P < 0.001$). However, the interactive effect of Group x condition did not show any significance ($P = 0.828$) [Tables 3 and 4].

Gypsum compatibility according to ADA specification

In the impregum group, under dry condition, gypsum compatibility according to ADA specifications was satisfactory in 42 (84%) samples whereas it was satisfactory in 37 (74%) samples under moist condition. The difference between dry and moist conditions was not significant statistically ($P = 0.220$). In the aquasil group, both dry and moist conditions showed satisfactory gypsum compatibility in 43 (86%) samples with statistically non-significant difference ($P = 1.000$) [Table 5].

Gypsum compatibility according to macroscopic evaluation

In the impregum group, under dry condition, none of the samples showed Grade 1, 8 (16%) samples showed Grade 2, 18 (36%) samples showed Grade 3, and 24 (48%) samples showed grade 4; whereas under moist condition none of the samples showed

Table 1: Results for evaluation of surface detail reproduction for two groups of impression materials under two conditions according to ADA specification

Group	Condition	Surface detail reproduction		Total	χ^2	df	*P* value
		Satisfactory	Unsatisfactory				
Impregum	Dry	49	1	50	2.837[a]	1	0.092
	Moist	45	5	50			Not significant
	Total	94	6	100			
Aquasil	Dry	50	-	50	-	-	-

Table 2: Results of surface detail reproduction of two groups of materials under two conditions according to macroscopic evaluation by chi-square tests

Group	Condition	Surface detail reproduction		Total	χ^2	df	*P* value
		Satisfactory	Unsatisfactory				
Impregum	Dry	32	18	50	24.00[a]	1	<0.001
	Moist	8	42	50			Highly significant
	Total	40	60	100			
Aquasil	Dry	34	16	50	7.890[b]	1	0.005
	Moist	20	30	50			Significant
	Total	54	46	100			

0 cells (0.0%) have expected count less than 5. 0 cells (0.0%) have expected count less than 5

Table 3: Results of dimensional stability for two groups of materials under two conditions (deviation from standard) using ANOVA

Group	Condition	*n*	Mean	Standard deviation
Impregum	Dry	50	0.012	0.483
	Moist	50	−0.273	0.281
	Total	100	−0.130	0.418
Aquasil	Dry	50	−0.458	0.570
	Moist	50	−0.776	0.738
	Total	100	−0.617	0.675
Total	Dry	100	−0.223	0.576
	Moist	100	−0.524	0.610
	Total	200	−0.374	0.611

Table 4: Results of two-way ANOVA test for the evaluation of dimensional stability for two groups of impression materials under two conditions

Source	Type III sum of squares	df	Mean square	*F*	*P* value
Corrected model	16.402a	3	5.467	18.502	<0.001*
Intercept	27.916	1	27.916	94.470	<0.001*
Group	11.840	1	11.840	40.069	<0.001*
condition	4.547	1	4.547	15.389	<0.001*
Group *	0.014	1	0.014	0.047	0.828
Error	57.918	196	0.295		
Total	102.235	200			
Corrected total	74.319	199			

*a-R Squared=0.221 (adjusted R Squared=0.209). *P<0.001; Highly significant*

grade 1, 14 (28%), 13 (26%), and 23 (46%) samples showed Grade 2, Grade 3, and Grade 4, respectively, by macroscopic evaluation. The difference among grades of gypsum compatibility under two conditions was statistically not significant. (P = 0.292). In the aquasil group, under dry condition, none of the samples showed Grade 1, 7 (14%) showed Grade 2, 32 (64%) showed Grade 3, and 11 (22%) showed Grade 4 gypsum compatibility by macroscopic evaluation. Under moist condition, none of the samples showed Grade 1, 7 (14%) showed Grade 2, 37 (74%) showed Grade 3, and 6 (12%) showed Grade 4 gypsum compatibility. The difference among grades of gypsum compatibility under two conditions was statistically not significant (P = 0.400) [Table 6].

DISCUSSION

In this *in vitro* study both the materials performed almost equally when evaluated for surface detail reproduction, under both the conditions, according to the modified ANSI/ADA specification no. 19 (P = 0.092). Johnson *et al*. and Walker *et al*.[3] studied the effect of surface moisture on detail reproduction of elastomeric impressions and concluded that PE produced the best detail under moist conditions compared to polyvinyl siloxane (PVS) materials.[2,3] The results of this study for surface detail reproduction are

Table 5: Results of gypsum compatibility for two groups of materials under two conditions according to ADA specification using chi square tests

Group	Condition	Gypsum compatibility		Total	χ^2	df	*P* value
		Satisfactory	Unsatisfactory				
Impregum	Dry	42	8	50	1.507[a]	1	0.220 Not Significant
	Moist	37	13	50			
	Total	79	21	100			
Aquasil	Dry	43	7	50	0.000[b]	1	1.000 Not Significant
	Moist	43	7	50			
	Total	86	14	100			

0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.50. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.00

Table 6: Results of gypsum compatibility for two groups of materials under two conditions according to macroscopic evaluation using chi square tests

Group	Condition	Gypsum compatibility				Total	χ^2	df	*P* value
		Grade 1	Grade 2	Grade 3	Grade 4				
Impregum	Dry	0	8	18	24	50	2.464[a]	2	0.292 Not Significant
	Moist	0	14	13	23	50			
	Total	0	22	31	47	100			
Aquasil	Dry	-	7	32	11	50	1.833[b]	2	0.400 Not Significant
	Moist	-	7	37	6	50			
	Total	-	14	69	17	100			

0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.00. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.00 not in accordance with the abovementioned studies as both the materials performed equally under both the conditions. This might be because of improved hydrophilicity of PVS impression materials.

When surface detail reproduction was macroscopically evaluated, both the materials performed better in dry condition than the moist condition with a highly significant statistical difference. ($P < 0.001$). In moist conditions, aquasil performed significantly better than impregum ($P = 0.005$). Petrie *et al*. studied the surface detail reproduction by macroscopic evaluation of smooth surfaces for PVS impression materials tested under dry, moist, and wet conditions, and concluded that both materials performed satisfactorily under dry conditions but performed inconsistently under moist and wet conditions.[1] The results of this *in vitro* study for PVS materials using macroscopic evaluation to assess surface detail reproduction were in accordance with the abovementioned study.

In the present study, regarding dimensional accuracy, both the materials were well within the ADA standards, except for PVS material under moist conditions; moreover, PE performed better than PVS under both dry and moist conditions. Petrie *et al*.[1] and Walker *et al*.[3] studied the effect of moisture on the dimensional stability of PE and PVS impression materials and concluded that moisture did not cause a significant adverse effect on the dimensional accuracy between PVS and PE impression materials. Except for the results of PVS under moist condition, PE under both the conditions and aquasil under dry condition were in accordance with the above mentioned studies. Previous studies have reported that PE impression material exhibit dimensional expansion as a result of moisture absorption. In the present study, PE materials showed both expansion as well as contraction whereas aquasil showed only expansion; this appeared to be material dependent, suggesting that both the materials have significant differences in their formulations.[10-16]

When the gypsum compatibility was evaluated by modified ADA specification no. 19, the surface detail reproduction under both dry and moist conditions was not statistically significant for both PE ($P = 0.220$) and PVS ($P = 1.000$). Under dry condition, both the materials performed equally whereas, under moist conditions, PVS performed better than PE. When the gypsum compatibility was evaluated by macroscopic evaluation, both under dry and moist conditions, the difference of gypsum compatibility was not statistically significant for both PE ($P = 0.386$) and PVS ($P = 0.400$).

Kumari *et al*. studied the gypsum compatibility with five different addition silicone impression materials and concluded that not all addition silicone impression materials tested were compatible with various type IV gypsum products used in the study.[17] These results were not in accordance with the present study, which may be because of using different types of elastomers and die stone combinations in the present study.[18-21] Further studies are required to study various properties of elastomeric impression materials and their compatibilities with various gypsum products.

CONCLUSION

Regarding dimensional stability, both impregum and aquasil performed better in dry condition than that in moist condition; when impregum and aquasil were compared under two conditions, impregum performed better than aquasil.

When both the materials were tested for surface detail reproduction, according to the modified ADA specification under dry and moist conditions, both performed almost equally. When tested for surface detail reproduction according to macroscopic evaluation, impregum and aquasil performed better in dry condition compared to moist condition. In dry condition, both the materials performed almost equally. In moist condition, aquasil performed significantly better than impregum.

When both the materials were tested for gypsum compatibility according to modified ADA specification, in dry condition both the materials performed almost equally, in moist condition aquasil performed better than impregum. When they tested for gypsum compatibility according to macroscopic evaluation, impregum performed better than aquasil in both the conditions.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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