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Evaluation of the Effect of Temperature Changes on the Dimensional Stability of poly (Vinyl Siloxane) Impression Material.

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I. Introduction

The accuracy and dimensional stability of addition silicone impression materials have been the subject of numerous investigations and is well established [1, 2, 3, 4, 5, 6, 7]. Research has primarily focused on 1) degree of polymerization shrinkage [8] 2) length of storage time [9] 3) effect of humidity [10]. Few studies have addressed the effect of temperature on the dimensional stability of impression material.Mccabe JF [11] stated that addition curing silicone do not produce a by-product during polymerization so that any change in dimension depends on thermal contraction of the material when the temperature is reduced from the mouth temperature of 37ºc to room temperature of 23ºc. Marco corso [12] reported that though poly vinyl siloxane showed less consistent results when impressions were heated to 40ºc followed by allowing the impressions to reach room temperature of 23ºc, it tended to improve the accuracy of the impression by expansion.

The investigations have mainly focused on the manipulation of the elastomeric impression materials at room temperature of 23ºc.The purpose of the study was to investigate the effect of extreme heat and cold ranging from 28 ºc to 40 ºc of room temperatures on the dimensional stability of two commonly used elastomeric impression materials as the impression may be subjected to different temperature while making impression namely, the storage temperature, mouth temperature (while making the impression) and room temperature (while pouring the cast). The effect of refrigeration (2 ºc ± 1 ºc) was also evaluated.

II. Materials And Methods

The dimensional stability of impressions was assessed indirectly by measuring vertical and horizontal grooves on the gypsum casts recovered from impressions of master model that consisted of metal die according to the ADA specifiction number 19, in the form of cone that represented a premolar crown preparation having a base of 10 mm diameter and the height of 12 mm. The combined taper from the base of the cone to the tip was 7º. The dimensions measured on the master die were 1) diameter (a-b) 2) Vertical height (line c-d). Three measurements were made of each distance with a traveling microscope having a variability of ± 2 micrometer and the mean values were calculated. Line a-b measured 5.953mm. Line c-d measured 10.04mm. The width of lines was 0.02mm (Fig-1, 2, 3). The dimensions of the gypsum dies were then compared with those of the metal master die (control) [13, 14].

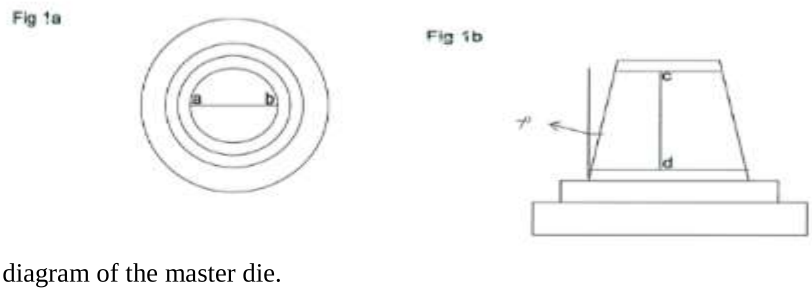

Fig1 Schematic diagram of the master die.
Fig1a: Top view of the cone
Fig1b: Side view of the cone

Two commercially available poly vinyl siloxane impression materials were selected. 1) Provil (novo) Heraeus Kulzer GmbH and COkg. Germany - Medium viscosity (batch no-EN 24823) And Light Bodied Consistency (Batch No En4823). 2) Reprosil Dentsply/Caulk, De – Medium Body Viscosity (Batch No 026402(6/95) And Light Bodied Consistency (026400(6/95).Heraeus Kulzer GmbH and COkg. Germany - Medium viscosity (batch no-EN 24823) And Light Bodied Consistency (Batch No En4823). 2) Reprosil Dentsply/Caulk, De – Medium Body Viscosity (Batch No 026402(6/95) And Light Bodied Consistency (026400(6/95). A total of Forty eight impressions were made of standardized master die. A prototype custom tray was fabricated with acrylic resin 48 hours prior to use on the master die and a uniform thickness of 2mm of impression material was provided [15] with the handles on either side of top edge of the tray to hold. Mechanical retention was provided with perforations **(Fig-4).** It was stored in water at room temperature. Tray adhesive was applied evenly to the tray 30 minutes prior to making impressions.

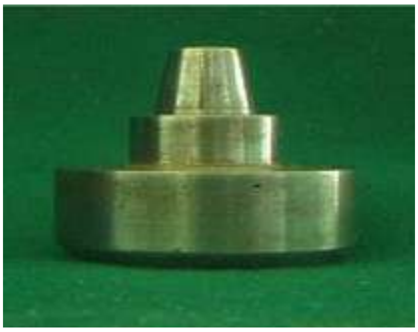

Fig2 Steel Master Die: Showing Vertical Groove

Fig3. Top View Of Master Die Showing Horizontal groove.

Polyvinyl siloxane impressions were made by loading the custom tray with medium viscosity material and injecting low viscosity material on the die and placed in a temperature controlled room at 37°c$\pm$ 1ºc to reproduce the intraoral temperature for 10 minutes prior to separation from master die. After separation the impressions were rinsed with room temperature distilled water for 20 seconds and air-dried. They were poured using type IV Dental Stone with water powder ratio following manufacturer's instructions. Dies were separated from the impression 60 minutes after pouring. A traveling microscope with resolution of 0.5micrometer was used to measure the horizontal and vertical lines. The impressions and dies were divided in to 4 groups for each impression material of six samples each.

In group –A impression materials were stored at 28ºc $\pm$ 1ºc for 24 hours. After pouring the cast, impressions were allowed to set at 28ºc $\pm$ 1ºc for one hour.

In group –B impression materials were stored at 2ºc $\pm$ 1ºc for 30 minutes before making impression. After pouring the cast, impressions were allowed to set at 28ºc $\pm$ 1ºc for one hour.

In group – C impressions were made at 37 ºc with impression materials stored at 40ºc $\pm$ 1ºc for 24 hours. After pouring the cast, impressions were allowed to set at 40ºc $\pm$ 1ºc for one hour.

In group –D impression materials were stored at 2ºc $\pm$ 1ºc for 30 minutes and then impressions were allowed to set at 40ºc $\pm$ 1ºc for one hour. After recovery of the stone dies, the dimensions of lines a- b and c-d were measured using traveling microscope. Three measurements were made for each line and means were calculated. The dimensions of each group were compared to those of the master die. Data analyzed using the ANOVA and Duncan Multiple Test.

Fig4 Steps In Making Custom Tray

III. Results

All the recorded means in table-1 represent average of three readings of horizontal lines and vertical lines.The dimensional variation in the stone dies in comparison to those of master die were recorded and calculated as the percent deviation from the standard.

Table-1 shows standard deviation values and percent deviation. Group A produced contraction for both the materials at 28 °c.

1. Group B produced greater dimensions of stone dies than the steel die for both the materials.
2. Group C produced greater dimensions of stone dies than the steel die for both the materials.
3. Group D produced greater dimensions of stone dies than the steel die for Provil (novo) and smaller dimensions for Reprosil.

A one factor ANOVA (table-2) with stain less model as a control was used to test the differences between the groups. After finding the significant differences, a comparison of individual means was performed by the Duncan Multiple Range Test (Table 3). Standard 't' test was used to compare between the groups (Table 4a and 4b). Storage temperatures were statistically significant for Reprosil ($p < 0.05$) that showed significant group differences for the vertical line. For the horizontal line significant difference was found between group A and B. For Provil (novo) p-value was insignificant ($p > 0.05$) for horizontal line where as significant for vertical line between group A and C.

Table 1: **SD Values and percentage deviation**

A) For Horizontal Line:

Groups	**Provil (Novo)**			**Reprosil**		
	Mean (Mm)	**SD**	**% Deviation**	**Mean** (Mm)	**SD**	**% Deviation**
Group-A (28^0C)	5.9850	0.05958	0.5375	-5.9457*	0.06662	-0.1226*
Group-B (2^0C)	6.1583	0.40167	3.4486	6.1017	0.13438	2.4979
Group-C (40^0C)	6.0483	0.09704	1.6008	6.0467	0.09048	1.5739
Group-D (2^0C)	6.000	0.07510	0.7895	-5.9517*	0.12123	-0.13*
Baseline Reading	5.9530	0.00000		5.9530	0.00000	

B) For Vertical Line:

Groups	**Provil (Novo)**			**Reprosil**		
	Mean (Mm)	**SD**	**% Deviation**	**Mean** (Mm)	**SD**	**% Deviation**
Group-A (28^0C)	-9.7600	0.36000	-2.7888	-9.9767*	0.07815	-0.6304*
Group-B (2^0C)	-10.0133	0.23746	-0.2655	10.1500	0.08532	1.0959
Group-C (40^0C)	10.0983	0.07111	0.5806	10.1233	0.09201	0.8296
Group-D (2^0C)	10.0600	0.09940	0.1992	-9.8717*	0.12608	-1.6762*
Baseline Reading	10.0400	0.00000		10.040	0.00000	

Table 2: Results of one Way Analysis of Variance

Dependent Variable	Source	Sum of Squares	Df	Mean Square	F	Sig.
Provil: Horizontal Line (mm)	Between Groups	.154	4	.038	1.069	.39
	Within Groups	.900	25	.036		
	Total	1.054	29			
Provil: Vertical Line (mm)	Between Groups	.435	4	.109	2.706	.05
	Within Groups	1.005	25	.040		
	Total	1.440	29			

Reprosil: Horizontal Line (mm)	Between Groups	.120	4	.030	3.307	.02
	Within Groups	.227	25	.009		
	Total	.347	29			
Reprosil: Vertical Line (mm)	Between Groups	.307	4	.077	10.152	.00
	Within Groups	.189	25	.008		
	Total	.495	29			

Note: Small significance values (<. 05) indicate group differences

Table 3: Descriptive statistics along with the results of Duncan Multiple Range Test (DMRT)

Groups	Provil (novo)				Reprosil			
	Horizontal Line (mm)		Vertical Line (mm)		Horizontal Line (mm)		Vertical Line (mm)	
	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
Group-A (28^0C)	5.9850^a	.02432	-9.7600^a	.14697	-5.9457^a	.02720	-9.9767^b	.03190
Group-B ($28^0C + 2^0C$)	6.1583^a	.16398	-10.0133^b	.09694	6.1017^b	.05486	10.1500^d	.03483
Group-C (40^0C)	6.0483^a	.03962	10.0983^b	.02903	6.0467^{ab}	.03694	10.1233^{cd}	.03756
Group-D ($40^0C + 2^0C$)	6.0000^a	.03066	10.0600^b	.04058	-5.9517^a	.04949	-9.8717^a	.05147
Group- E (Baseline)	5.9530^a	.00000	10.0400^b	.00000	5.9530^a	.00000	10.040^{bc}	.00000

Note: **Duncan Multiple Range Test (DMRT):** The same superscripts in the columns indicate no significant difference

Table-4: Standard't' test between groups:

a) For Horizontal Line:

Groups	Provil (novo)			Reprosil		
	t- value	p-value	significance	t- value	p-value	significance
Gp-A & Gp-C	1.18	P>0.05	NS	2.216	P>0.05	NS
Gp-A & Gp-B)	1.055	P>0.05	NS	2.55	P>0.05	S
Gp-C & Gp-D)	0.86	P>0.05	NS	1.56	P>0.05	NS

b) For Vertical Line:

Groups	Provil (novo)			Reprosil		
	t- value	p-value	significance	t- value	p-value	significance
Gp-A & Gp-C	2.27	P>0.05	S	2.992	P>0.05	S
Gp-A & Gp-B)	1.45	P>0.05	NS	3.70	P>0.05	S
Gp-C & Gp-D)	0.78	P>0.05	NS	3.97	P>0.05	S

Note: S- significance, NS- nonsignificance

IV. Discussion

Numerous factors influence the physical and mechanical properties of the elastomeric impression materials. Various factors such as size, rigidity of impression tray, manipulation of material itself, impression technique, temperature, humidity, length of storage time etc. are the factors need to be considered. In the investigation the effects of storage temperature of two commercially available polyvinyl siloxane impression materials at two different temperatures were evaluated by using a precision steel die with a horizontal groove measuring 5.953mm in length on the top of the cone and vertical groove measuring 10.04mm in length. Impression materials were stored at 2ºc, 28ºc, and 40 º c. Polyvinyl siloxane impression were made with single stage impression technique at 37ºc±1ºc by injecting low viscosity material on the die and loading the custom tray with medium viscosity. Impressions were poured at room temperatures of 28ºc and 40ºc. The impressions and dies were divided into 4 groups of six samples each. A total of 48 impressions were made. A travelling microscope with a resolution of 0.5 micrometer was used to measure the horizontal and vertical lines.

Cooling of the impression from mouth temperature to room temperature has been correlated with decrease in dimensional accuracy because of high coefficient of thermal contraction of elastomeric impression materials [16]. In this study the dimensions of the dies were small at 28ºc and agree with the previous works [12] and larger at higher temperature (40ºc) than the mouth temperature.Storage of impression at 2ºc followed by allowing the impression to reach room temperatures (28ºc, 40ºc) rsulted in inconsistent results between both materials. Marco corso et al [12] reported that when elastomeric impression materials were stored at 23ºc, they showed decrease in the dimensions. Chee et al [14] observations differed in that all the gypsum dies were larger in dimensions when stored at 2ºc & 23ºc and poured at 23ºc. Chee et al, [14], Araujo and Jorgensen [17] reported that reheating an elastomeric impression to 37ºc for 15 minutes before pouring the master cast improved accuracy. The magnitude of changes observed varied in the studies.

The measurements in table 1 show a significant difference in the dimensions of stone dies as compared to those of master die at 28ºc and 40ºc. The scatter of percent variation varied from -0.1348% to + 0.5375% for horizontal line and – 2.788% to – 0.6304% for vertical line in case of stone dies retrieved from group-A impressions. Among all groups Group A (at 28^0C) produced least dimensional changes in the diameters.

Horizontal Line:

Reprosil The material demonstrated contraction at 28^0C and expansion at 40ºc. Refrigeration of the material at 2ºc showed expansion with the room temperature 28ºc and contraction with the room temperature 40ºc.Provil (NOVO):The material demonstrated expansion at 2ºc, 28ºc, 40ºc. Storage temperatures were statistically insignificant ($p>0.005$).

Vertical line:

Both the materials demonstrated contraction after storage at 28ºc and expansion at 40ºc. After storage at 2ºc both materials differed in their behaviour. The standard‘t’ test revealed significant differences between 28ºc and 40ºc for both materials ($P<0.005$) However refrigeration of the material did not had any significant effect on Provil ($p>0.005$). The material showed contraction in group-B and expansion at group-D. Where as refrigeration had statistically significant effect on Reprosil ($p<0.005$). It showed expansion in group-B & contraction in group-D (Table 4b). Overall dimensional changes observed did not differ greatly from master die measurements ($p >0.005$) in all the groups for both materials. In the study for the horizontal and vertical lines, both the variables - the material used and storage temperature influenced the results. However differences were extremely small and not clinically relevant. The horizontal measurements in group-A showed decrease in diameter up to 7-63 micrometer. The C-group showed increase in diameter from 58-95 micrometer. Gorden et al. [18] reported that the deviation of 60 micrometer increase in diameter could adequately provide die space needed for fabrication of crowns without need of applying spacer.

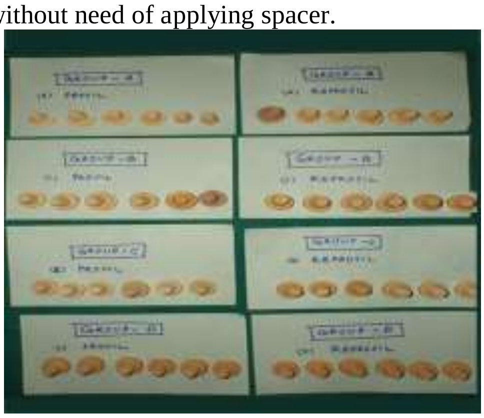

Fig5 Dies Prepared At Different Temperatures

V. Conclusion

A full arch impression may distort in three dimensions and distortion in this third dimension was not evaluated in this study. Within the limitation of this study with the assumption that the linear expansion of the die stone is negligible it could be concluded that dimensional stability of the polyvinyl siloxane impression materials at different temperatures differed. Dimensional changes were not only related to the temperature but also it was related to the material used. Though each group differed individually, there was no significant difference from the master die measurements. Both the materials were comparatively accurate when compared with the master die. However Provil produced consistent results between groups than Reprosil. Within the limitation of the study following conclusions were drawn:

1. Storing and pouring the impression at 28ºc resulted in the decreased dimensions.
2. When materials were stored and poured at 40ºc resulted in expansion that compensated partially for the polymerization shrinkage.
3. Though cooling the impression material produced inconsistent results, it did not decrease the accuracy of gypsum dies. Thus this method would be an acceptable means of extending working time when this would prove clinically advantageous.

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