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To compare and evaluate the effect of temperatures ranging from mouth temperature (37˚C) to 50℃ on the dimensional stability of commercially available polyvinyl siloxane impression material

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Abstract

Introduction: The impressions have to be transported to distant places and sometimes due to various contingencies. They cannot be poured immediately by the clinician. In such conditions regulation of temperature is a big challenge that might affect the dimensional stability of the impression material being used. An affected impression cannot produce an accurate prosthesis. The wide range of newer available elastomeric impression materials is a boon to dentistry due to its dimensional stability and accuracy under various conditions.

Materials and Method: A total of 30 impressions were made to evaluate the effects of different temperatures (40˚C and 50˚C). The impressions were made by two step putty/light body technique. A uniform storage time of 1 hour was maintained for all the impressions. Resultant impressions were poured in stone and subjected to evaluation using travelling microscope with accuracy of 1 mm or 1µ. The control group was stored at 23˚C for 1 hour. The control group was also poured in stone and subjected to evaluation using travelling microscope.

Results: The addition silicone impression material had exceptionally good dimensional stability at different storage temperatures as compared to other elastomeric impression materials. A statistically insignificant change in dimensions of die was observed for all storage temperatures.

Conclusion: It was concluded that polyvinyl siloxane maintained accuracy under all storage conditions and was dimensionally stable under adverse conditions.

Keywords: Polyvinyl siloxane (Aquasil), Dimensional stability, Storage temperature.

Introduction

A dental impression is an imprint of teeth and mouth from which positive reproduction (casts) can be made. An accurate impression of dental and dentoalveolar structures is important for a perfect fit of the prosthesis. The success of prosthesis in terms of fit, accuracy and long life are dependent on the impression materials.[1]

A clinician may require a cast for numerous reasons.[2] Casts are not only made for the purpose of prosthesis fabrication but can also be a desired need for the sake of evaluating the anatomic relationship of teeth with each other. The accuracy of the cast/die absolutely depends upon the impression material used, so impression making is one of the most important and inevitable step in branch of prosthodontics.[3] Starting from dentures to crown/bridges and recent of all the implant supported prosthesis, we need impressions for everything.

Dental impressions need to be taken seriously. Dental impressions are bad enough to make anyone hate going to the dentist. If you have ever needed a crown, bridge or veneer or complete denture, then you have experienced the agony of dental impressions. There's nothing worse than waiting those two to five excruciating minutes for the goey material to set. But now its 21st century and we have evolved from tackey materials to materials that are easy and comfortable to use.[4]

If accuracy of impression is vital for clinical success of any prosthesis, then dimensional stability of an impression material cannot be overlooked. In this fast evolving world, the clinicians due to host of contingencies are not able to pour their impressions immediately. Sometimes the transportation of these impressions to distant laboratories under various temperature conditions makes it a more challenging affair. India being a tropical country is divided into various temperature zones. Where north India faces extremes of temperature reaching almost about 47℃ (average) and 4℃ (average), there is south India which burns in summers and stays pleasant in winters. Humidity is another cherry on the cake to complicate the management and handling of impressions. The desire of every clinician is an accurate cast for a perfect fit prosthesis. An accurate impression must have registered accurate details of the teeth and their contiguous oral integuments. A dimensionally stable impression material would be able to sustain various temperatures and still be able to accomplish the work of an accurate fit prosthesis.

The rubber base impression materials are widely evolving as a material of choice now a days.[5] Chemically, there are four kinds of elastomers used in impression making: polysulfide, condensation–

polymerizing silicone, addition polymerizing silicone, and polyether. These materials were introduced way back in 1950's.[6,7] Dimensional changes occurring in the elastomeric impression materials depend largely on the degree of polymerization. Due to inferior physical properties of condensation polymerizing silicones and polysulfide, they are not used frequently in clinical practice. The polyether and addition polymerizing silicone materials are available in various consistencies which is why they are becoming materials of choice. The hydrophilic nature, acceptable accuracy, high pseudo plastic behaviour and ability to be disinfected without significant loss of accuracy holds it in good state. Due to so many positives, dentists choose it to be a material of choice when impressions have to be transported to long distance laboratory.[8,9]

Nevertheless, extreme changes in temperature that could occur during routine transportation of impression is unknown. Temperature changes may affect the accuracy of final or the interim prosthesis obtained. In past, several studies have been done to evaluate the dimensional stability of additional polymerizing silicones under the effect of temperature ranging up to 40˚C. Still ambiguity exists about temperature variation above 40˚C.

The present study was conducted to evaluate the effect of different temperatures (40℃, 50℃) on dimensional accuracy of polyvinyl siloxane.

Materials and Method

The present study was undertaken to evaluate the effect of different temperatures on the dimensional stability of commercially available brand of polyvinyl silioxane. (Table I) Tray adhesive of particular brand as provided by manufacturer was used Type IV die stone (Kal Rock Kalabai, Mumbai, India) was used for pouring the samples.

Table I: Details of polyvinyl siloxane used

Group	Manufacturer	Trade Name	Consistency
1	Dentsply	Aquasil	Putty , Light Body(Fig 1)

Armamentarium used:

1. Stainless steel master die (Nanak Workshop , Patiala)(Fig. 2)
2. Stainless steel custom tray (Nanak Workshop , Patiala)(Fig. 3)
3. Flexible rubber bowl (Golden & co)
4. Stainless steel mixing spatula (straight), (API Germany)
5. Weighing Balance (Kerro , Taiwan)
6. Calibrated measuring cylinder (Pyrex India)
7. Bard parker handles no 4 (API Germany)
8. No15 surgical blade (Glass – Van India)
9. Vibrator (Unident India)
10. Vacuum press (Bio star, India)
11. Spaces sheets (2mm) , (Dentsply India)
12. Tray adhesive (Aquasil, caulk / Dentsply)(Fig 4)
13. Acrylizer (Bison, Intensive industries, New Delhi, India) (Fig 5)

Measurement Instrument: Travelling microscope by (Parco India) (Fig 6)

Method

Fabrication of the master die: A machined standard steel master die of size 32×27 mm was fabricated with four identical posts at the Nanak workshop, Patiala, Punjab (Fig 2). Each post had a uniform taper of 6 degrees simulating four complete crown tapered abutments. Master die was firmly attached to the platform so as to immobilize it during impression making.

Reference cross grooves were prepared on the abutments occlusal surfaces. Four reference points A, B, C and D (Fig. 7) were marked on the Centre point of each cross groove. A custom made spacer (Fig. 8) with a uniform thickness of 1mm was fabricated on each post with the help of a vacuum press machine (Bio star, India) to provide uniform space for light body impression material (Aquasil Ultra Impression material,) while making the impressions. Various dimensions of the master die are shown in Table II.

Table II: Various dimensions of the master die

Diameter of each post	7mm
Height of each post	6mm
Distance between the reference post A&B	22.11mm
Distance between the reference post B&C	16.00mm
Distance between the reference post C&D	22.11mm
Distance between the reference post D &A	16.00mm

Fig. 1: Aquasil Impression material(Putty)

Fabrication of metal custom impression tray

A specially prepared metal custom impression tray having a uniform space of approximately 2 mm for the addition silicone impression material was fabricated for making the impressions. A flat base was used for precise positioning of metal custom impression tray during impression making. Reference lines were made on one surface of metal custom impression tray and on die platform for a similar placement of the metal custom impression tray every time the impression was made.

Impression of the master die

Step 1: All the impressions of the master die were made in a metal custom impression tray at room temperature. Master die was stabilized on a flat base.

Step 2: A thin, even coat of a tray adhesive was applied to the metal custom impression tray (Fig. 6) and allowed to dry for 15 minutes according to the manufacturer's recommendations.

Step 3: A vacuum formed plastic spacer of 1mm was placed over each post on the master die, and the preliminary heavy body putty impression (Aquasil) was made with metal custom impression tray.

Step 4: The plastic spacers were removed before making a final impression to make uniform space of 1mm for light body.

Step 5: Then light bodied polyvinyl siloxane impression material (Aquasil Ultra Impression material) was mixed using auto mix dispensing cartridge at room temperature and loaded into the metal custom impression tray within the working time as recommended by the manufacturer.(Fig. 9)

The tray was seated gently over the master model while maintaining finger pressure until the material was set. To compensate for polymerization at room temperature, impressions were allowed to set for twice the manufacturer's recommended setting time (4 minutes) as indicated in ADA specification number 19 for laboratory testing.

(Note: Mixing time and all other parameters were kept as per manufacturer's recommendations. In all cases, the first 3 cm of paste extruded from the mixing tip was discarded to ensure that adequate mixing of the material had occurred. The homogenous mixed material was dispensed into the metal custom impression tray.)

Step 6: After the impression material was set, impression was removed from the die with a straight pull. (Fig 9) Impressions with air entrapment or without details were discarded. Impressions were placed or immersed in water bath at their respective temperature for 1 hour. **(23° C, 40° C, 50° C) (Table III)** In this manner a total number of 30 impressions were made using polyvinyl siloxane impression material and their resultant models were obtained. (Fig. 10)

Preparation of Stone Cast: The impressions were air dried. Then dental stone type IV was mixed in a clean bowl according to manufacturer's instructions (23 cc water and 100 gram powder) and transferred to mechanical vibrator to avoid entrapment of bubbles. Impressions were poured in small increments with type IV dental stone (Kal Rock Kalabai, Mumbai, India). The die stone was then allowed to set.

Table III: Number of impressions made at different temperatures

	23° C Control group	**40° C**	**50° C**
Dentsply	10	10	10

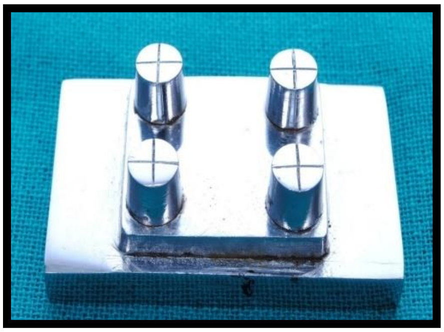

Fig. 2: Master Die

Fig. 3: Custom tray

Fig. 4: Tray adhesive

Fig. 5: Acrylizer

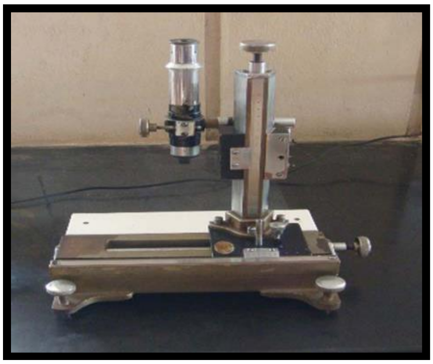

Fig. 6: Travelling microscope

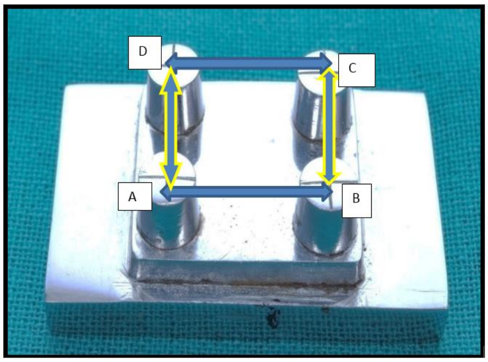

Fig. 7: Reference points for measurements

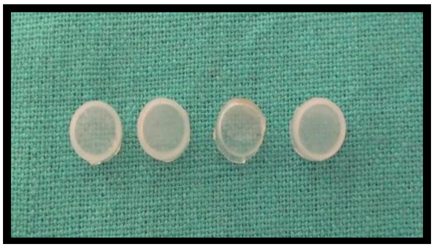

Fig. 8: Spacers

Fig. 9: Auto mixing dispensing gun

Measuring technique: A total of four measurements (2 horizontal and 2 vertical) were made on the control group cast (10 samples) and on 20 samples casts using travelling microscope with accuracy 0.01mm. For every measurement combination of each site was measured three times. The mean value and standard deviation of three readings were calculated and reported for the two horizontal and two vertical measurements.

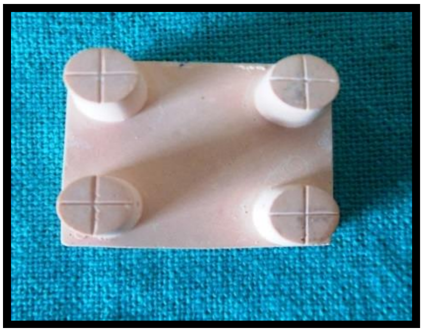

Fig. 10: Obtained model

Fig. 11: Measurements of reference points

Statistical Analysis

In statistical analysis, there were 2 groups, each 10 values each. For each group mean and standard deviation were calculated. Two related groups were compared with their means using students ANOVA and Post-Hoc Bonferroni Test.

Results and Observation

Table IV: Mean of measurements of stone casts at reference points A-B,B-C,C-D,D-A for samples(brand aquasil) at 23℃

Sample no.	A-B	B-C	C-D	D-A
1	22.11	16	22.11	16
2	22.11	16	22.11	16
3	22.11	16	22.11	16
4	22.11	16	22.11	16
5	22.11	16	22.11	16
6	22.11	16	22.11	16
7	22.11	16	22.11	16
8	22.11	16	22.11	16
9	22.11	16	22.11	16
10	22.11	16	22.11	16
Mean	22.110	16.00	22.110	16.00

Table IV shows the mean of the measurements of reference points A-B,B-C,C-A,D-A of 10 stone casts poured with type IV die stone after storing the samples at 23˚C for 1 hour

Table V: Mean of measurements of stone casts at reference points A-B,B-C,C-D,D-A for samples (brand aquasil) at 40℃

Sample no.	A-B	B-C	C-D	D-A
1	22.10	16.01	22.10	16.00
2	22.12	16.01	22.12	16.01
3	22.11	16.00	21.90	16.03
4	22.35	16.00	22.35	16.00
5	22.11	16.03	22.11	16.03
6	22.18	16.02	22.18	16.00
7	22.18	16.02	22.18	16.00
8	22.19	16.00	22.19	16.04
9	22.10	16.00	22.10	16.00
10	22.28	16.00	22.28	16.03
Mean	22.172	16.009	22.151	16.014

Table V shows the mean of the measurements of reference points A-B,B-C,C-A,D-A of 10 stone casts poured with type IV die stone after storing the samples at 40˚C for 1 hour

Table VI: Mean of measurements of stone casts at reference points A-B,B-C,C-D,D-A for samples (brand aquasil) at 50℃

Sample no.	A-B	B-C	C-D	D-A
1	22.18	16.01	22.00	16.00
2	22.15	16.00	22.15	16.00
3	22.15	16.00	22.15	16.00
4	22.10	16.01	22.10	16.00
5	22.32	16.01	22.32	16.00
6	22.13	16.01	22.13	16.03
7	22.11	16.00	22.11	16.04
8	22.11	16.00	22.11	16.01
9	22.10	16.01	22.10	16.00
10	22.33	16.02	22.33	16.00
Mean	22.168	16.007	22.150	16.008

Table VI shows the mean of the measurements of reference points A-B,B-C,C-A,D-A of 10 stone casts poured with type IV die stone after storing the samples of Group I (brand aquasil) at 50˚C for 1 hour.

Table VII shows the mean difference in linear dimension change of master die between the reference points after immersion of impressions at 40 and 50° C.

Table VII: Mean difference in linear dimensional change

Group	Temperature (°C)	A-B		B-C		C-D		D-A	
		Mean difference	**P value**	**Mean difference**	**P value**	**Mean difference**	**P value**	**Mean difference**	**P value**
Aquasil	40	-0.062	1.000	-0.009	0.044*	-0.041	1.000	-0.014	0.051
	50	-0.058	1.000	-0.007	0.243	-0.040	1.000	-0.008	0.992

Discussion

An accurate impression resulting in an accurate fit prosthesis is what every clinician desires. The journey from desire to reality has to be dealt walking through a lot of challenges. Due to a number of factors, a clinician is not able to pour his/her impressions by self immediately. The transportation of these impressions for fabrication of prosthesis is another challenge that affects the accuracy of prosthesis. Firstly an impression is subjected to a range of temperature variations like mixing at room temperature ranging from 22˚C to 25˚C to mouth temperature ranging from 35˚- 37˚

Many factors are important for choice of material for impression making. Out of all accuracy and dimensional stability are the most important factors for making a material a choice of operator/clinician for impression procedure.[10]

Out of all the available materials, the addition type polyvinyl siloxane (PVS) has been reported to be most accurate and dimensionally stable.[6,11] They are extremely popular because of their combination of excellent physical properties, handling characteristics and dimensionally stability.

Since the introduction of elastomeric impression materials to dental profession in 1950's, they have improved and become more popular over time[12]. The American Dental Association (ADA Specification no.19) granted by the American National Standard Institute on October 4, 1976, identifies such materials as "Non Aqueous Elastomeric Dental Impression Materials".(McCabe,1980). According to their elastic properties and dimensional changes, they are classified into:

1. Very high viscosity
2. High viscosity
3. Medium viscosity
4. Low viscosity

Before the introduction of addition silicones, it was polysulfide also known as vulcanizing impression materials or mercaptan impression materials which failed to impress the dental fraternity due to its poor dimensional stability with time, potential for significant distortion and bad odor that caused discomfort to patients.[5] So the present study was carried out to evaluate the effect of different temperatures on the dimensional stability of polyvinyl siloxane. In this invitro study, a stainless steel master die was fabricated having four posts on it with uniform taper of 6 degrees on each post. The die fabricated was similar to master die used by Lerebke at al. These posts represented four abutments which had four reference points A, B, C, D on the occlusal surface to analyze the effect of different temperatures on dimensional stability of impression. The impressions were made with putty wash impression technique. This same technique was used by Johnson and Craig. They reported that impression made with this technique were most accurate as compared with other techniques.[8]

The impression of standardized stainless steel master die was made in a perforated stainless steel custom tray. All the impression were made at room temperature and obtained impressions were stored at different temperatures (23˚C,40˚C,50˚C) in an acrylizer for 1 hour and then poured with type 4 die stone.

To determine the linear dimensional changes, dimensions of master die between the reference points A-B, B-C, C-D, D-A were measured with help of travelling microscope capable of measuring upto 0.001mm. The same instrument was used by Johnson and Craig(1986)[8] in similar type of study.

It is evident that there was a tendency towards slight increase in all the dimensions as compared to control group but no specific pattern was observed. Also this change in dimensions was statistically insignificant. According to ADA Specification no.19 for elastomeric impression materials dimensional change should not be more than 0.50%. Results of present study were also within this limit.

William et al found that the addition silicone impression material had exceptionally good dimensional stability at different storage temperatures as compared to other elastomeric impression materials. A statistically insignificant change in dimensions of die was for all storage temperatures under study.

Summary and Conclusion

This study was planned with the objective of evaluating the effect of different temperatures on the dimensional stability of polyvinyl siloxane. The impression material used for this purpose was polyvinyl siloxane impression material.

The master die was fabricated based on the model as described by Lubke et al. All the impressions were dried and then they were poured with type IV gypsum products and obtained models were compared with control group casts with the help of traveling microscope. Dimensions of reference points (A-B, B-C, C-D, D-A) were measured for each stone casts and compared with control group casts. While comparing the stone casts obtained from two different groups at different temperatures of 40 ˚C, 50 ˚C, with control group casts(23℃), there were changes in the linear dimensions of reference points after storage of impression materials after 1 hour especially at 40℃.The vertical measurements of B-C at 40˚C for Aquasil showed significant difference in dimensions

All other changes in linear dimensions were insignificant.

Thus, in the light of the findings of present study, following conclusions can be obtained.

1. The addition silicone elastomeric impression materials maintained their accuracy after storage at different temperatures. Storing impressions under different conditions caused no adverse effect upon the accuracy of addition silicone elastomeric impression materials.
2. There was no significant change in the dimensions of stone casts obtained from impression material as compared to the dimensions of a master die.

So it was concluded from the present study that Polyvinyl siloxane impression materials used in this study maintained their accuracy and were dimensionally stable.

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