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Original Research

Effect of temperature changes on the dimensional stability of elastomeric impression materials

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Abstract:

Background: The purpose of this study was to evaluate the changed dimensions of dies obtained from impressions made with different combinations of addition sillicones which were subjected to variations in storage temperature.

Materials & Methods: 45 die stone models were obtained of 45 impressions of which 15 each were stored at three different storage temperatures(25°C, 37°C and 42°C). 15 impressions each were made using one impression technique. The measurements of the dies made from the impressions were measured with the help of Profile Projector with a accuracy of 0.001mm.

Results: The results were statistically analyzed. The results indicated the significant decrease in dimensions when the storage temperature reduced from the mouth temperature. As compared to this there was a marginal increase in overall dimensions of all variables when storage temperature increased.

Conclusion: More changes were seen in putty/light body combination followed by monophase and least in heavy/light body combination.

Key Words: Dimensional changes, polyvinylsiloxanes, profile projector, storage temperature

Introduction

Distortion of an impression is not caused by the material alone. It results from many factors such as space between tray and tooth preparation, impression technique, by excessive seating pressure, an impression removed before polymerization is completed and storage conditions.

Addition silicones are very accurate when used in clinical dental practice. The dimensional accuracy of a material is usually time dependent. A material may be highly dimensionally accurate soon after its initial polymerization but less accurate after storage for a period of time. It is important that an impression material remain dimensionally accurate even if there is a delay in pouring of impressions.

The literature reports that linear contraction for condensation and addition silicones at 24 hours is 0.7 and 0.22% respectively[1].Several factors need to be taken into account in order to minimize deformation of the impressions, including, among others: a) polymerization shrinkage, b) release of byproducts, c) contraction /expansion due to temperature changes, d) incomplete recovery of deformation due to the viscoelastic behavior of these materials, e) use of acustom tray made of acrylic resin that has not completed its polymerization and therefore still undergoes polymerization shrinkage, f) lack of adhesion of the material to the tray, g) lack of mechanical retention of materials for which the adhesive is ineffective, h) development of elastic properties in the material before placing the tray in the mouth, i) excess material, j) continuous pressure on the impression material that has already developed elastic properties, k) tray movement during polymerization, l) early tray removal, and m) removal of the impression from the mouth using an incorrect technique[1]. Clinical success of fixed prosthodontic procedures is dependent in part upon the dimensional accuracy of elastomeric impression materials and impression procedures.[2]

Owing the credit to various research projects,[3,4] addition polyvinyl siloxane (PVS) impression material, with excellent surface detail reproduction, exhibiting best dimensional stability among the elastomers, low shrinkage and low deformation properties, strongly influenced its selection as the impression material of choice for numerous studies, research and development projects.

In our country, there exists wide range of variation in temperature from 13º-15º C, 23º-25º C and it can go up to

40º-45ºC. With such high variation in temperature, some amount of inaccuracies may occur in the set impression material.

Addition silicone impression materials are more widely used than other impression materials because of their excellent dimensional stability, but thermal contraction of the materials cannot be avoided because of the temperature difference between the oral cavity and room temperature. In general, the temperature of the oral cavity approaches 37°C, and room temperature is 23°C, for pouring stone, so 14°C of thermal difference takes place and affects the contraction of the materials. For precise replication of the oral tissue, the amount and direction of contraction, the anatomy of the teeth, and the shape of the trays are important issues. Studies[5,6,7] related to the dimensional stability considered time dependence, condition of storage, and measurement of the original model and cast.

Figure 1: Materials used in the study.

Figure 2: Original master model.

Related to this aspect, there are very few studies that have addressed possible effects of temperature on dimensional stability. Understanding the need for an accurate impression and its clinical significance, in this study an attempt has been made to put forward the data that may aid the dental surgeon in selecting the best combination of rubber base impressions when subjected to storage conditions like temperature variation to remain dimensionally stable before pouring the cast, which will help to predict the accuracy of impression not just after being made but remain accurate till pouring of impression.

Materials and Methods

The present in vitro study was conducted in the Department of Prosthodontics, Dental College Chandeshwar, Azamgarh with the objective to evaluate the changed dimensions of dies obtained from impressions made with different combinations (putty/light body,heavy body body/light body combination impression material and monophase impression material of polyvinyl siloxane consistencies when subjected to different storage conditions.

Materials and Trade Name (Figure 1)

1. Putty - GC international
2. Light body - GC international
3. Heavy body - GC international
4. Monophase - Aquasil dentsply international Inc.

Standard die mould fabrication

The modified master model was fabricated with two prepared abutments a premolar and molar representing a clinical situation for three unit fixed partial denture. The diagrammatic representation of the master model and the reference areas of measurements are shown in Figure 2 and Figure 3.

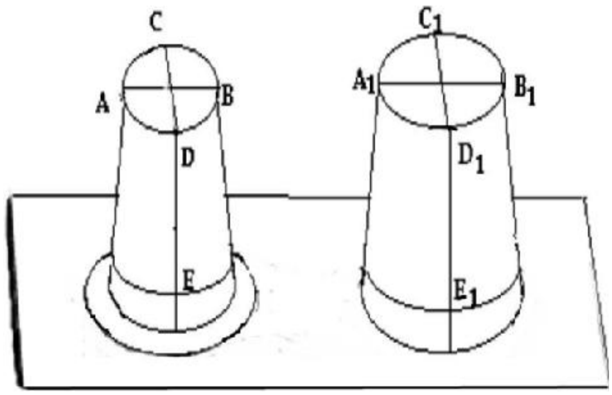

Figure 3: Reference points used in the study.

The abbreviations used are:

Mesio-distal (Premolar) AB

Mesio-distal (Molar) A1B1

Bucco-lingual (Premolar) CD

Bucco-lingual (Molar) C1D1

Height (Premolar) DE

Height (Molar) D1E1

Inter-abutment (Inner) BA1

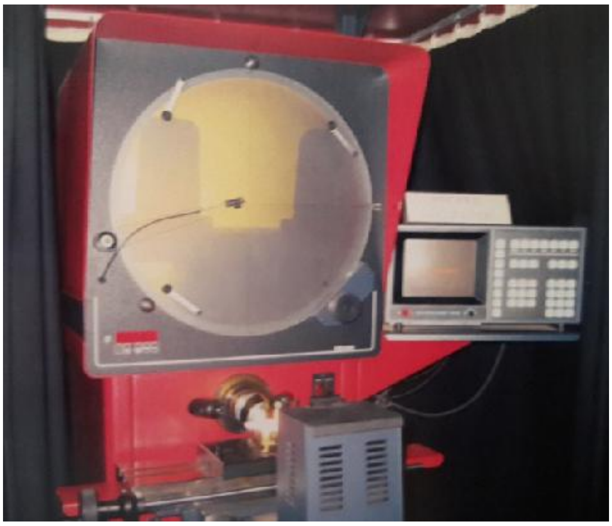

Figure 4: Profile projector.

A total of 45 die stone models obtained from 45 impressions of which 15 each were stored at three different storage temperatures and 15 impressions each were made using one impression technique. The parameters included the mesiodistal width of premolar and molar, buccolingual width of premolar and molar, height of premolar and molar and interabutment distance. The variables were three different temperatures a) 25°C, b) 37°C, c) 42°C and putty/light body combination, heavy body/ light body combination and monophase impression materials. Custom trays were fabricated for heavy body and light body and monophase PVS impressions and stock trays for putty and light body PVS impressions. A uniform thickness spacer of 2mm was adapted on the master die using modelling wax. A putty impression was made and it was poured with dental stone. Acrylic resin custom trays were fabricated over the model obtained. Tray acrylic resin was used to prepare the custom trays with a uniform thickness of 2mm with tray resin extending into orientation key holes .All the trays were cured in the pressure pot under 2½ lb pressure at room temperature. Stock trays were fabricated by using Aluminum sheets Perforations were made using a no.6 round bur at a distance of 1cm from each other for retention of the impression material. Trays were used for making the impression after 24hrs of its fabrication. Thus a total of 30 custom trays and15 stock trays were prepared. Resin trays were stored in water.

Table 1: Statistical comparison (t-test) of original dimensions and means of changed dimensions between different reference points on dies of original master model and dies obtained from Heavy body/light body combination impressions when stored at 25°C, 37°C, 42°C.

Groups	Standard value	Mean	S.D.	t-value	p-value	Remarks
B_1(PMD)	0.8850	0.8856	0.0005	2.4490	0.0046	S*
B_2(PMD)	0.8850	0.8864	0.0008	3.5000	0.0049	S*
B_3(PMD)	0.8850	0.8874	0.0005	9.7980	0.0050	S
B_1(PBL)	0.9100	0.9122	0.0004	11.000	0.0000	S
B_2(PBL)	0.9100	0.9144	0.0008	11.000	0.0000	S
B_3(PBL)	0.9100	0.9178	0.0008	20.846	0.0000	S

Table 2: Statistical comparison (t-test) of original dimensions and means of changed dimensions between different reference points on dies of original master model and dies obtained from monophase impressions when stored at 25°C, 37°C, 42°C.

Groups	Standard value	Mean	S.D.	t-value	p-value	Remarks
C_1(PMD)	0.8850	0.8874	0.0008	6.0000	0.0000	S
C_2(PMD)	0.8850	0.8896	0.0005	18.779	0.0000	S
C_3(PMD)	0.8850	0.8916	0.0005	26.944	0.0000	S
C_1(PBL)	0.9100	0.9116	0.0005	6.5320	0.0000	S
C_2(PBL)	0.9100	0.9128	0.0004	14.000	0.0000	S
C_3(PBL)	0.9100	0.9146	0.0005	18.779	0.0000	S

Impressions for storage temperature groups (37°C and 42°C) prior to pouring with die material were stored in incubator for 24 hours. 15 impressions from each system were poured with Kalrock die stone with W:P ratio of 23ml:100gms . The die stone was mixed under 10 mbar vacuum for 30 seconds and poured using a vibrator. The dies were allowed to set further for 1 hour at room temperature before being recovered from the impressions. All the measurements between various reference marks on the dies were recorded by a profile projector (Figure 4) with a accuracy of 0.001mm. The mean of each dimensions measured, three times on the master die, was used as the basis for determining the relative change in that dimension of each sample according to relationship.

The measurements made on dies obtained from the different combination impressions were compared with the dies of original master model. For heavy body/ light body combination (B_1 group) and monophase (C_1 group) stored at 25°C the molar mesiodistal width on the dies obtained from the combination impressions were 1.3506cm (t=2.4495 at p=0.3020) and 1.3502cm (t=0.5345 at p=0.0566) respectively and in the dies of original master model it was 1.350cm. [Table 1, Figure 5]

The same patterns in changes in dimensions were seen for all the variables in between A_2, B_2, C_2 groups. For putty/light body combination (A_2 group) stored at 37°C the molar mesiodistal width on the dies obtained from the combination impression was 1.3512cm (t=3.2071 at p=0.1772) and in the original master model it was 1.350cm. For heavy body/ light body combination (B_2 group) and monophase (C_2 group) stored at 37°C the molar mesiodistal width on the dies obtained from

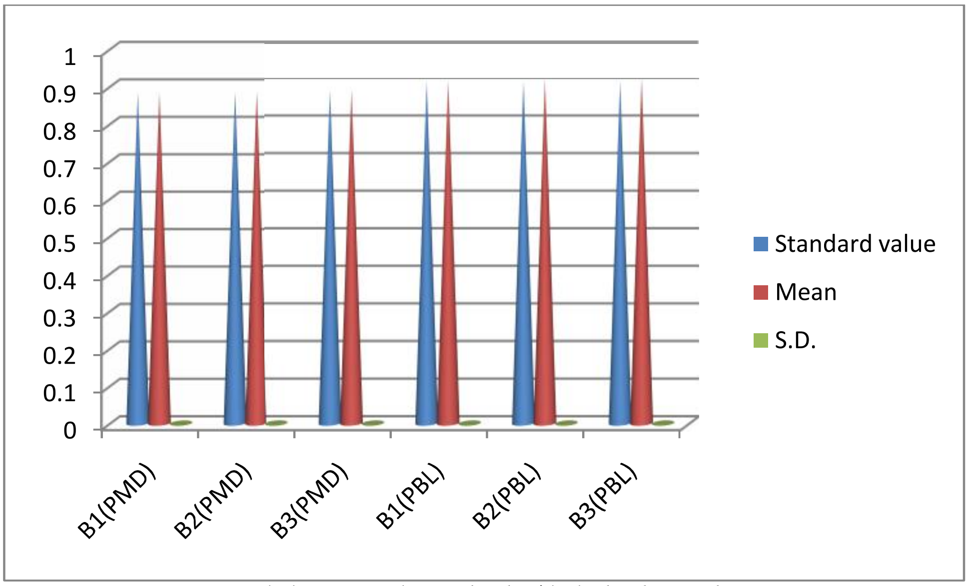

Figure 5: Dimensional changes in heavy body / light body combination impressions.

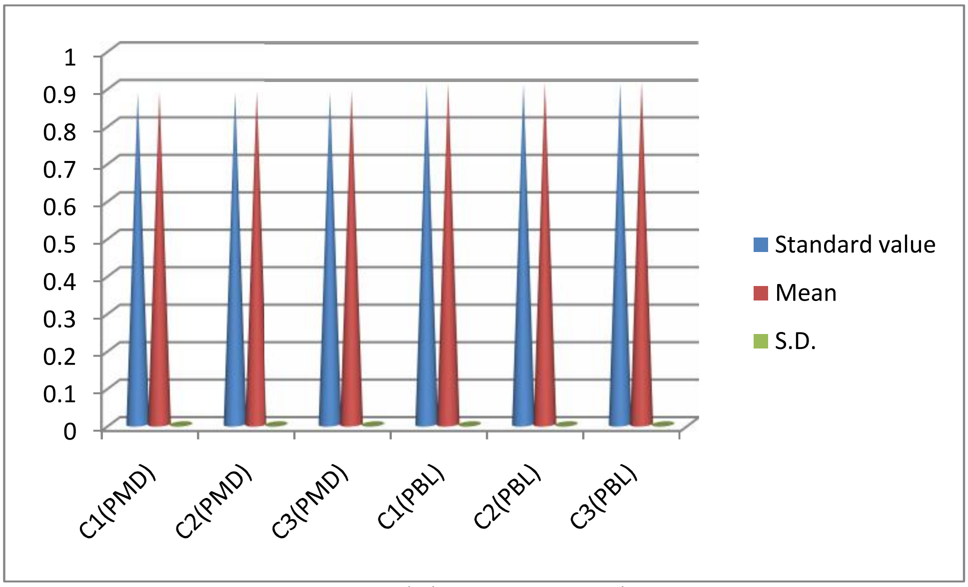

Figure 6: Dimensional changes in monophase impressions.

combination impression was 1.3512cm (t=6.0000 at p=0.3060) and 1.3512 (t=3.2071 at p=0.0568) respectively as compared to original master die which was 1.350cm. Same was the case for all the variables between A_2, B_2, C_2 groups. [Table 2, Figure 5]

The statistical analysis [Table 4] showed the significant increase in dimensions of the stone dies obtained from different impressions and stored at different temperatures changed significantly from the original dimensions except the premolar mesiodistal width of stone dies obtained from

Table 3: Statistical comparison (t-test) of original dimensions and means of changed dimensions between different reference points on dies of original master model and dies obtained from putty/light body, heavy body/light body and monophase impressions when stored at 25°C, 37°C, 42°C.

Groups	Standard value	Mean	S.D.	t-value	p-value	Remarks
A_1(MPH)	1.4000	1.4020	0.0044	1.0000	0.0001	NS
A_2(MPH)	1.4000	1.4120	0.0044	6.0000	0.0002	S
A_3(MPH)	1.4000	1.4180	0.0044	9.0000	0.0004	S
B_1(MPH)	1.4000	1.4020	0.0044	1.0000	0.3440	NS
B_2(MPH)	1.4000	1.4060	0.0054	2.4490	0.3442	S*
B_3(MPH)	1.4000	1.4080	0.0083	2.1381	0.3444	S*
C_1(MPH)	1.4000	1.4040	0.0054	1.6330	0.6406	NS
C_2(MPH)	1.4000	1.4060	0.0054	2.4495	0.6408	S*
C_3(MPH)	1.4000	1.4080	0.0083	2.1381	0.6410	S*

For putty/light body combination (A_3 group) stored at 42°C the molar mesiodistal width on the dies obtained from combination impressions was 1.3516cm (t=6.5320 at p=0.1780) as compared to the original dies of master model which was 1.350. For heavy body/ light body combination (B_3 group) and monophase (C_3 group)

putty/light body combinations impressions.

Likewise the buccolingual width of the molar, the height and buccolingual mesiodistal width of the premolar and interabutment distance changed significantly for the A_1, A_2, A_3 as well as all the dimensions of the dies of other remaining groups i.e. B_1, B_2, B_3, C_1, C_2, C_3. [Figure 7, 8]

Table 4: Statistical comparison (t-test) of original dimensions and means of changed dimensions between different reference points on dies of original master model and dies obtained from putty/light body, heavy body/light body and monophase impressions when stored at 25°C, 37°C, 42°C.

Groups	Standard value	Mean	S.D.	t-value	p-value	Remarks
A_1(IAD)	1.660	1.664	0.0001	8.5732	0.0001	S
A_2(IAD)	1.660	1.666	0.0001	13.4164	0.0000	S
A_3(IAD)	1.660	1.668	0.0008	21.9154	0.0000	S
B_1(IAD)	1.660	1.668	0.0001	17.8823	0.0000	S
B_2(IAD)	1.660	1.671	0.0001	24.5960	0.0000	S
B_3(IAD)	1.660	1.673	0.0008	35.2780	0.0000	S
C_1(IAD)	1.660	1.668	0.0008	21.9154	0.0000	S
C_2(IAD)	1.660	1.671	0.0008	29.9330	0.0000	S
C_3(IAD)	1.660	1.674	0.0001	28.9850	0.0000	S

stored at 42°C the molar mesiodistal width on the dies obtained from combination impression was 1.3516 (t=6.5320 at p=0.3100) and 1.3514 (t=5.7155 at p=0.0571) respectively as compared to original dies of master model which was 1.350cm. same was the case for all variable between A_3,B_3, C_3 groups. [Table 3, Figure 6]

Discussion

Impressions of the master die using various combination techniques of PVS impressions were made as per the manufacturer's guidelines. An automix impression gun was used to dispense the homogenous mix on the master model and for loading of the tray. The use of automix system eliminated the variation in setting time and working time and produced a uniform streak free mix. The loaded impression tray was seated over the master model and allowed to set.

interabutment horizontal dimensions, no statistical differences were noted between impression material types when using a custom tray. Stock trays produced unreliable results for all the materials tested. Chong Lin Chew et al[3]

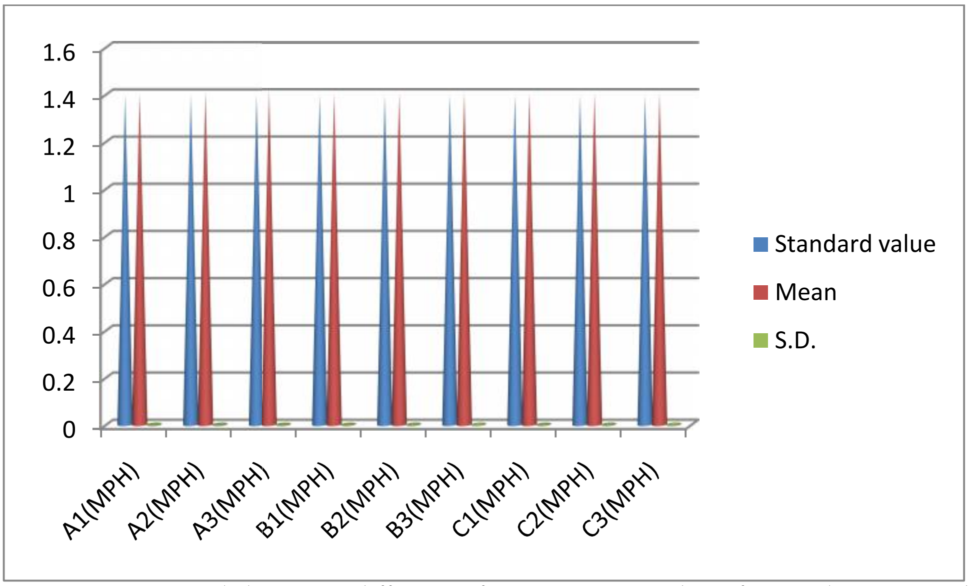

Figure 7: Dimensional changes at different reference points on dies of original master model.

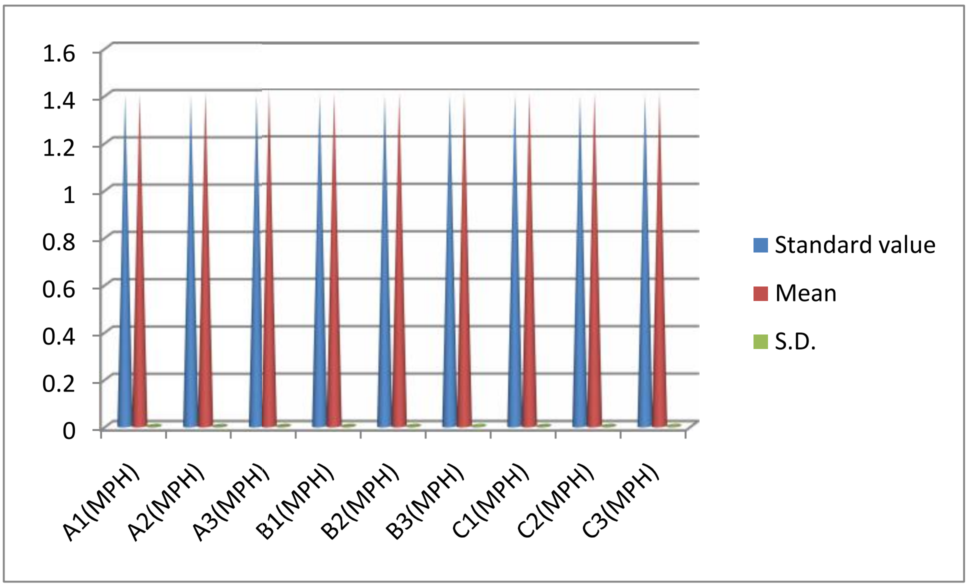

Figure 8: Dimensional changes at different reference points of original master model.

The temperature changes play a pivotal role in influencing the dimensional stability of elastomers. As reported by Anusavice KJ[1], an increase in the temperature accelerates the curing rate of all elastomeric impression materials and therefore decreases both the setting and working times.Conversely cooling increases the working time of elastomeric impression materials. Boulton et al[2] demonstrated that polysulphide is the least accurate impression material for both vertical and horizontal individual abutment dimensions. However, for evaluated the dimensional accuracy of chilled impression material and the effect on accuracy of reheating the impression to mouth temperature prior to pouring.

This is in accordance with Curso M[4] who stated that cooling of the elastomeric impression from mouth temperature to room temperature has been correlated with a decrease in dimensional accuracy because of a high coefficient of thermal contraction of elastomeric impression materials. He also reported that storage of impressions at a temperature higher than the one at which the impressions were made caused a progressive expansion of the material. Storage of impressions at a lower temperature, followed by allowing the impression material to reach room temperature, consistently resulted in an overall expansion of the impressions. This expansion improved the accuracy of the impression both in the horizontal and vertical dimensions. Dentists should have the opportunity to select materials which have the properties with which they are comfortable and yet which do not sacrifice accuracy and stability.[5]

The literature describes two ways of evaluating the dimensional stability of the impression materials: one by studying the stability of the impression material itself, and the other by measuring casts made from an impression[6,7]. The latter should consider the setting expansion of the plaster, which would compensate part of the elastomer polymerization contraction.

In another study done by Panichuttra[8], the dimensional accuracy of all PVS materials decreased between 1hour, 1day and 1 week. Thus the storage of impressions itself plays important role in dimensional accuracy of elastomeric impression materials.

Purk[9] evaluated the effect of temperature on the dimensional accuracy of an addition silicone and a polyether, subjecting the impressions to -10, 24 and 66ºC, concluding that addition silicones underwent greater dimensional changes than the polyether, and that those changes could have clinical implications.

The limitations of the study included:

1) Only one brand of addition silicone impression material was considered. The results can vary with different brands.
2) Impressions were poured by hand. So, they cannot be considered as standard.
3) The extraoral procedure eliminated intraoral tissues, fluids etc and different arch forms.
4) Absence of undercuts.

Owing to this there is a need to do extensive research in this aspect.

Conclusion

There was a relative increase in the dimensions of the dies obtained from the different combination impressions. As the temperature increased, there was a relative increase in the dimensions of the dies. In this study more amount of changes in dimensions were seen in putty/light body impressions. The least amount of changes in dimensions were seen in heavy body/ light body impressions at all storage temperatures.So it can be concluded from this study that the heavy body/ light body impressions were most accurate at 25°C and change in dimensions were not significantly influenced by increase in storage temperatures.

However as the storage temperature was increased to 37°C and 42°C there was significant change in all the measurements of dies obtained from impressions made using putty/light body and monophase impression materials.The results, foregoing discussion and conclusion of this study amply prove that filler particle size, contents and / or the combination of dissimilar viscosities influence the thermal diffusivity and magnitude and direction of thermal expansion and / or contraction. However, contrary to this observation, monophase impression material was found to be most unstable dimensionally when subjected to increase in storage temperatures.

Clinical Significance

From the results and ongoing discussion it is apparent that the use of custom tray and heavy body /light body combination of rubber base materials and the storage of such impressions at 25°C produced relatively more accurate dies than the other combinations and storage temperature. Therefore it is advised to use the custom tray and combinations of heavy body/ light body material for making the impression and storing at temperature less than the mouth temperature.

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