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# Dimensional Accuracy and Surface Detail Reproduction of Hydrophilic Vinyl Poly Siloxane Impression Material Tested Under Dry and Moistened Salivary Conditions: An Invitro Study

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## ABSTRACT

**Aim**: The purpose of the study is to compare dimensional accuracy and surface details under dry and moist condition of polyvinylsiloxane impression material.

**Materials and Methods:** The study samples were assigned two groups based on the condition in which they were made. Group A consisted of casts obtained from impressions made in moist salivary condition (n=12). Group B consisted of casts obtained from impressions made in dry condition (n=12). Impressions of master model were made by using hydrophilic vinyl polysiloxane by two step putty-wash technique and working casts were obtained. Dimensional accuracy was measured by comparing the inter-abutment distance in each cast to the master model, by using a profile projector with an accuracy of 0.001mm. Surface detail reproduction was evaluated by use of criteria, continuous replication of at least 2 of the 3 horizontal lines. Statistical analysis was done and results were obtained.

**Results:** The inter-abutment distance was significantly increased compared to the master model in both the groups ($P<0.05$). The moist condition significantly affected the dimensional change of 0.6%. The dry and moist conditions had a significant effect on the detail reproduction of the material ($P<0.05$). Under dry condition the impression material satisfactorily replicated the details 100% of the time. Under moist condition, 58% of the impressions were judged satisfactory.

**Conclusion:** Presence of moisture caused a significant adverse effect on the dimensional accuracy and surface detail reproduction of the hydrophilic polyvinyl siloxane impression material. The moisture control remains an important factor for successful impressions.

**Keywords:** Hydrophilic Vinyl Poly Siloxane, Moistened Salivary Conditions, Prosthodontics.

## INTRODUCTION

A major limitation of polyvinylsiloxane (PVS) impression materials has been their hydrophobicity. To overcome PVS hydrophobicity, manufacturers have incorporated surfactants (nonylphenoxy-polyethanol homologues) and marketed these materials as hydrophilic PVS. This should facilitate the wetting of moist oral tissues and tooth surfaces with the unset impression

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material and thus enhance surface detail reproduction. However, impression materials with hydrophilic structures may also be more prone to moisture absorption and resultant decreased dimensional accuracy.[1]

The surface detail reproduction and dimensional accuracy of impression materials play a major role in determining the extent to which indirectly produced prostheses and restorations will have an acceptable fit. Although there is a general acceptance that elastomeric materials are more accurate and precise than hydrocolloids there is a degree of uncertainty over the extent to which elastomers can be relied upon to produce acceptable impressions of moist surfaces.Traditionally this problem has been solved by suggesting that the dentist should thoroughly dry the area to be recorded. Over recent years some silicone products have been modified to increase their hydrophilic nature and this may improve the ability to record detail although there is some disagreement amongst researchers as to the extent of this improvement.[2]

Research into impression accuracy has relied heavily on in vitro tests rather than clinical in service evaluation. The reason being, clinically many variables conspire to produce inaccuracies. Also, it is easier to make measurements in the laboratory than in the mouth.The specification tests of the American Dental Association (ADA)(19) and British Standards Institution (BSI) (4269) are designed to consider individual properties.

The main thrust of these tests is to ensure that impression materials meet minimum requirements before marketing and to provide continuing quality control. The specification tests cannot reliably predict a materials accuracy under clinical conditions. It may be assigned that the tests are insufficiently comprehensive to give a full description of materials properties.There are many types of simulatory tests available but their main drawback is that none of them provides an absolute simulation of the mouth. Nevertheless, these simulatory tests can provide much useful information.[3]When hydrophilic Vinyl Poly Siloxane (VPS) impression material was used clinically in the presence of moisture in the form of water, saliva, crevicular fluid or blood, decreased accuracy of the produced impression was reported. This inaccuracy in the presence of moisture suggests that the VPS hydrophilic additives may not enhance the ability of the unpolymerized VPS to wet the oral tissues under partial or complete moisture conditions.[4]

The purpose of this investigation was to evaluate the dimensional accuracy and surface detail reproduction of hydrophilic PVS impression materials when used under dry and moistened salivary conditions.

## MATERIALS AND METHODS

The freshly extracted maxillary right second premolar and second molar were obtained, cleaned and disinfected. These teeth were positioned inversely in the frasaco rubber mold[Frasaco, Germany]and a wax model(Golden Dental products) is recovered (Fig.1). Maxillary right first molar is removed so as to simulate a clinical case of 3 unit fixed partial denture and the model is processed to obtain the master model made up of heat cure acrylic resin(Travalon) (Fig.2). The premolar is prepared to receive a porcelain fused to metal retainer and molar is prepared to receive a all metal retainer for a 3 unit fixed partial denture. Three grooves in bucco-lingual direction and two grooves (50μm width) in mesio-distal direction were placed on the occlusal surface so as to evaluate surface detail reproduction (Photo 14).

Fig 1: Frasaco wax model.

Fig 2: Master Model.

**Group A impressions :**

In this group impressions were made with a hydrophilic PVS[Express, STD, 3M ESPE, St. Paul, Minnesota, Lot No. 20051229 by full arch dentulous stock metal trays using a two step putty reline technique under moist condition.[20] In the first step a preliminary putty impression was made on the master model which was relieved with two layers of spacer wax[MP Sai Enterprises, Mumbai, India] (0.5mm thickness). Four occlusal stops were made by removing wax on the non functional cusp[21].Tray adhesive[3M, ESPE] was applied on to the inner portion of the tray and extending 2mm onto the outer walls and allowed to dry for fifteen minutes. Putty base and catalyst were hand mixed.The mix was loaded into a perforated metal stock tray[Jabbar Company No.3]. A total of 12 PVS putty custom trays were made (Fig.3). Before the wash impression was made a 100µL quantity of saliva was applied to the prepared surface via a micropipette saliva was removed from the surface by a short, gental blast of compressed air in the same way as a dentist would dry the prepared surface. Care was taken to ensure that the entire die was covered with a uniform layer of saliva avoiding any excess or beading.[5]In the second step light bodied impression material Vinyl polysiloxane injection type (light body) [Imprint II, 3M ESPE, St. Paul, Minnesota, Lot No. 4LGC1T1] was also dispensed into the putty tray and it was reseated over the master model accurately and was held in place for 10 minutes for the material to set.[1,4] After the setting time the air seal was broken with light pressure and the impression was recovered with a snap.

**Group B :**

12 impressions were made for this group in dry condition in similar manner as explained in group A (Fig.3). the only difference being, before making second step wash impression teeth were allowed to air dry and there was no application of saliva. Once the impressions were made,they were poured with dental stone[Asian Dental Products].

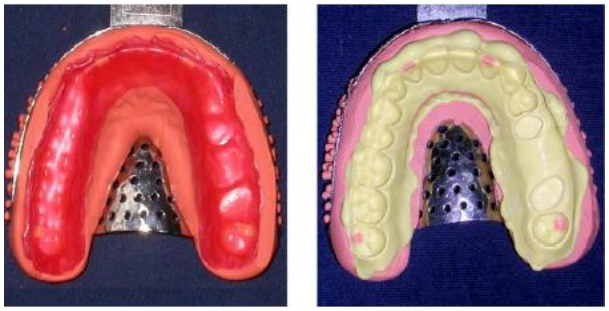


Fig 3: Preliminary putty tray with spacer & Completed impression.

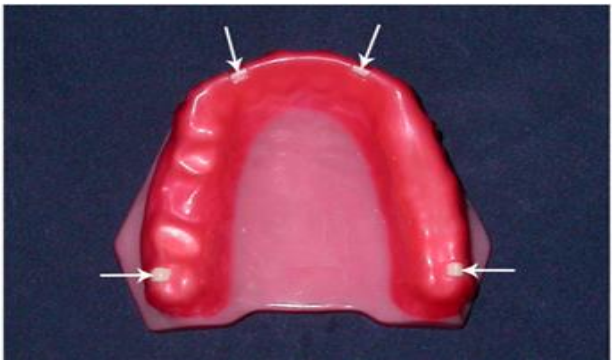


Fig 4: Wax spacer with stops.

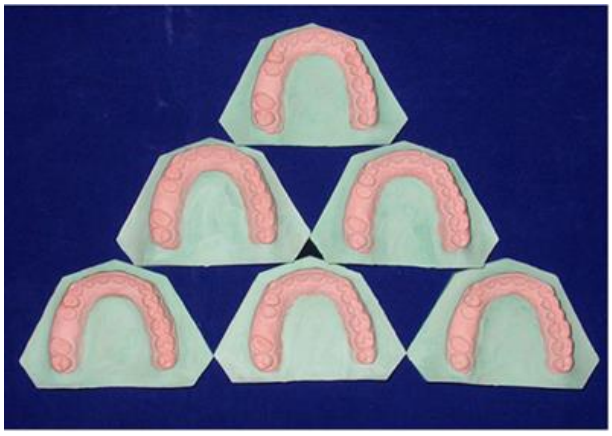


Fig 5: Group A casts.

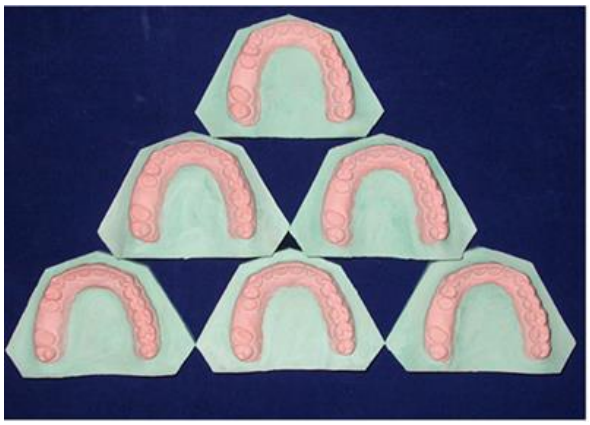


Fig 6: Group B casts.

The measurements of master model as well as group A and B casts were done in Mechanical Department, B.I.E.T. College, Davangere, using a Profile Projector[Nikon, Japan] with accuracy of 1 μm (Fig.7).


Fig 7: Cast being measured on profile projector.

The inter-abutment distance was measured from one pit to the other (Fig 8)For each cast the inter-abutment distance was recorded three times by the same operator and the mean value was calculated. The measurements of the master model and the stone casts obtained with group A and B impressions were tabulated and statistically analysed.

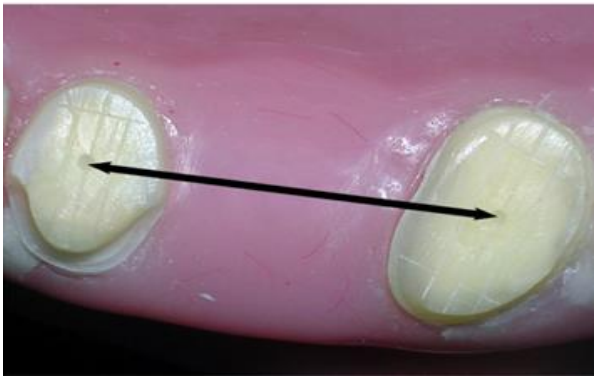


Fig 8: Reproducible reference points for measuring inter-abutment distance.

**STATISTICAL ANALYSIS**

Descriptive statistics like mean, standard deviation (SD) were calculated for all the groups and for differences with master model (MM). One way Analysis of Variance (ANOVA) was used for multiple group comparisons. Differences from the master model were analysed by paired 't' test. A P-value 0.05 or less was considered for statistical significance.

Table 1: Inter-abutment distance and mean for master model, Group A and Group B casts.

| Master model | | | | Sl. No. | Dry condition | | | | Moist condition | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reading I | Reading II | Reading III | Mean | | Reading I | Reading II | Reading III | Mean | Reading I | Reading II | Reading III | Mean |
| 17.721 | 17.722 | 17.733 | 17.725 | 1 | 17.701 | 17.713 | 17.721 | 17.712 | 17.871 | 17.812 | 17.893 | 17.859 |
| | | | | 2 | 17.76 | 17.733 | 17.762 | 17.752 | 17.883 | 17.851 | 17.862 | 17.865 |
| | | | | 3 | 17.743 | 17.75 | 17.741 | 17.745 | 17.832 | 17.811 | 17.831 | 17.825 |
| | | | | 4 | 17.842 | 17.853 | 17.89 | 17.862 | 17.903 | 17.892 | 17.903 | 17.899 |
| | | | | 5 | 17.801 | 17.853 | 17.81 | 17.821 | 17.862 | 17.841 | 17.832 | 17.845 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 6 | 17.741 | 17.76 | 17.743 | 17.748 | 17.743 | 17.721 | 17.743 | 17.736 |
| | | | | 7 | 17.792 | 17.8 | 17.763 | 17.785 | 17.844 | 17.812 | 17.83 | 17.829 |
| | | | | 8 | 17.761 | 17.773 | 17.744 | 17.759 | 17.8 | 17.84 | 17.83 | 17.823 |
| | | | | 9 | 17.842 | 17.841 | 17.833 | 17.839 | 17.881 | 17.903 | 17.864 | 17.883 |
| | | | | 10 | 17.722 | 17.754 | 17.744 | 17.740 | 17.813 | 17.812 | 17.844 | 17.823 |
| | | | | 11 | 17.741 | 17.853 | 17.763 | 17.786 | 17.832 | 17.892 | 17.743 | 17.822 |
| | | | | 12 | 17.76 | 17.8 | 17.721 | 17.760 | 17.881 | 17.903 | 17.831 | 17.872 |

Table 2: Mean inter-abutment distances with standard deviation.

| | Master model | Dry | Moist | F-value | P-value | Significance |
|---|---|---|---|---|---|---|
| Mean ± SD | 17.725 | 17.771 ± 0.0458 | 17.839 ± 0.0407 | 14.84 | < 0.001 | Highly Significant |

Table 3: Mean increase in dry and moist conditions (Paired 't' test).

| Master model | Conditions | Mean increase | Percentage increase | t-value | P-value | Significance |
|---|---|---|---|---|---|---|
| 17.725 mm | Dry | 0.046 ± 0.0458 | 0.3 | 3.48 | P < 0.01 | Very significant |
| | Moist | 0.114 ± 0.0407 | 0.6 | 9.71 | P < 0.001 | Highly significant |

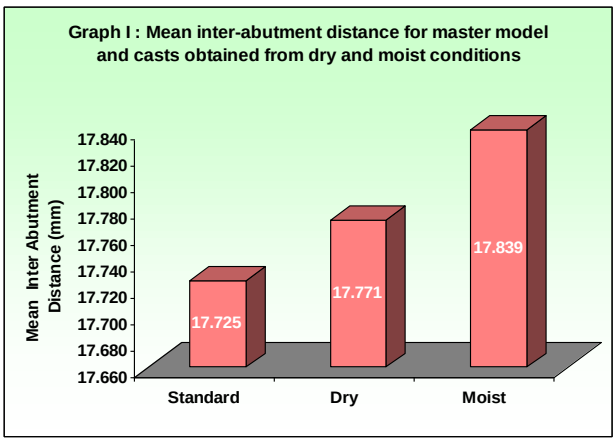
Table 4: Percentage dimensional change.

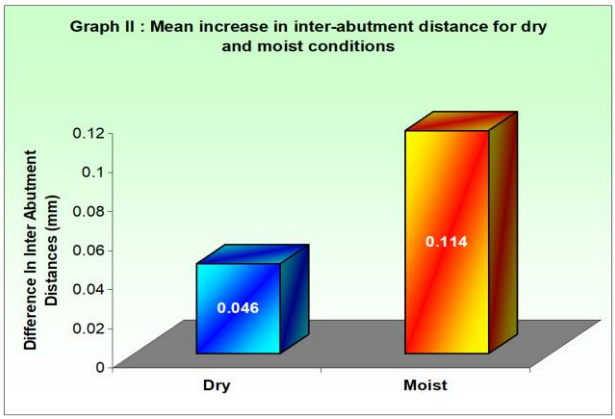
| Master model (mm) | Conditions | Percentage increase | Clinical significance | Significance |
|---|---|---|---|---|
| 17.725 | Dry | 0.3 | < 0.5 | Not significant |
| | Moist | 0.6 | > 0.5 | Significant |

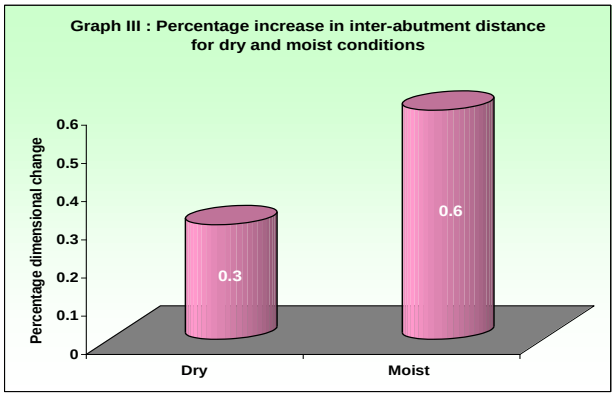
## RESULTS

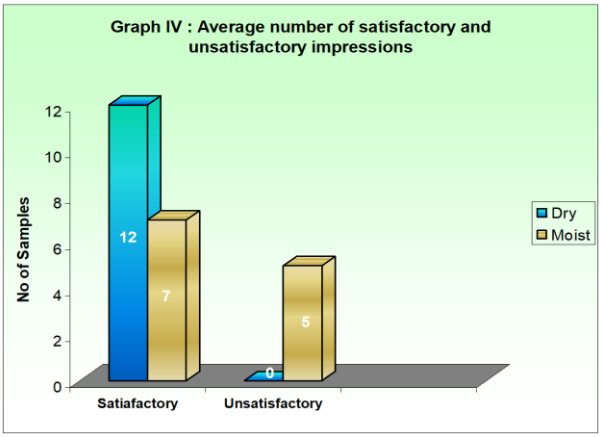
There was a significant (P<0.05) increase in interabutment distance for all the casts measured when compared to master model.It was observed that for Group A casts (obtained from impressions made under moist condition), the mean inter-abutment distance was 17.839 mm (SD ± 0.0407 mm). The difference from the master model was 0.114 mm indicating an increase in the inter-abutment distance of 114 µm (Graph II). The percentage difference was found to be 0.6% and was statistically significant (P<0.05). For Group B casts (obtained from impressions made under dry condition) the mean inter-abutment distance was 17.771 mm (SD ± 0.0458 mm). The difference from the master model was 0.046 mm indicating an increase in inter-abutment distance of 46 µm (Graph II). The percentage difference was found to

be 0.3% and was statistically not significant (P>0.05). The difference between the mean interabutment values of Group A casts and Group B casts was 0.068 mm indicating an increase in inter-abutment distance of 68µm. One way analysis of variance (ANOVA) revealed statistically significant difference (P<0.001) indicating that the dimensional accuracy of impressions made under moist conditions was affected to a greater extent as compared to those made under dry condition. The percentage dimensional change for Group B casts was 0.3% and for Group A casts was 0.6% which was significant clinically (Graph III).




## DISCUSSION

Vinyl polysiloxane materials have the ability to closely reproduce the details of the surfaces recorded demonstrating a high degree of dimensional accuracy, however it requires an absolutely dry field for producing such an acceptable and highly accurate impression.[4] Addition of certain non-ionic surfactants renders VPS hydrophilic, making them easier to pour. The term hydrophilic however has been misinterpreted to imply that the impressions can be made in a wet or moist environment. [19]Hydrophilic VPS has exhibited comparable dimensional accuracy to conventional VPS, when allowed to polymerize in a dry field.[13]

In the present study, since all the procedures were standardized for both the groups the difference in dimensional accuracy and stability among the test groups was assumed to be the effect of presence of moisture and the procedure in general.[18]The results from this investigation indicated that the dimensional accuracy of hydrophilic VPS impression materials was adversely affected by the presence of moisture &increase in mean inter-abutment distance for group A of 114 µm and was greater than the clinically acceptable range (0 – 90µm).[22]A similar increase of 46 µm in inter-abutment distance was seen in Group B which was within the clinically acceptable range of 0 – 90 µm. However this was not found to be statistically significant. In addition to the measurement of dimensional accuracy, this study also examined detailed reproduction of the hydrophilic VPS impression materials. Results of this study are conflicting with the latter findings. The hydrophilic VPS impression materials used in this study did not

always yield satisfactory impressions under moist conditions. Under moist condition only 58% of the impressions were satisfactory while 42% were unsatisfactory and failed to produce acceptable surface details. While under dry conditions 100% of impressions were satisfactory.

To evaluate the detail reproduction of the impressions made under dry and moist conditions with the hydrophilic VPS impression material, the impressions were evaluated according to criteria proposed under ADA specification No. 19, with certain modifications in master model and the procedure to make impression so as to simulate a clinical situation. ADA specification No. 19 states that an elastomeric impression material (light body) should be able to continuously reproduce 1 of the 20 μm horizontal lines in 2 of 3 specimens.[1]Use of saliva as a source of moisture in place of water was another modification used in the present study as compared to previous studies.Although the moist surface method used in the investigation may appear more clinically relevant but when compared to oral tissues there is moisture at the surface as well as within the bulk of the tissue. Water within the bulk of the tissue can diffuse to the surface during the recording of an impression. It would be very difficult to duplicate this type of moisture contamination in the laboratory.

## CONCLUSION

With in the limitations of this in vitro study the following conclusions can be drawn :Presence of moisture caused a significant adverse effect on the dimensional accuracy and surface detail reproduction of the hydrophilic polyvinyl siloxane impression material, though impressions made under dry condition also showed significant increase in inter-abutment distance. Dimensional change for the material in the dry environment was within the ADA standards of maximal shrinkage value of 0.5%. Using the criteria similar to ADA specification No. 19 to test detail reproduction, PVS impression material tested satisfactorily only under dry condition, while it met the criteria only 58% of the time under moist condition. The results of this investigation suggest that the moisture control remains an important factor for successful impressions.

## SUMMARY

Polyvinyl siloxane (PVS) impression materials have been on the market since mid-1970s and have garnered the lion's share of the contemporary market. PVS materials have remarkable dimensional accuracy and the best fine detail reproduction. The purpose of the present study was to evaluate the dimensional accuracy and surface detail reproduction of hydrophilic vinyl polysiloxane impression material, when used under dry and moistened salivary conditions.

The impressions were divided into two groups depending on the condition in which they were made. Group A consisted of casts obtained from impressions made in moistened salivary condition and group B consisted of casts obtained from impressions made in dry condition. The sample size was 24, 12 for each group. The impression were made of the master model prepared with extracted teeth having standard reference pits for measurements using a commercially available hydrophilic PVS material (imprint II, LV, express STD putty 3M ESPE). Impressions were immediately evaluated for detail reproduction as per the criteria ADA specification 19. Measurements for dimensional accuracy were done in the profile projector and results were statistically analyzed using paired 't' test and one way ANOVA. The results indicated that, there was a significant ($P<0.05$) increase in inter-abutment distance compared to master model in both the groups. However, the discrepancy was with in a clinically acceptable range for group B (dry condition). The mean dimensional change for group A (moist condition) was 0.6%and for group B (dry condition) was 0.3% compared to maximal acceptable limit of 0.5% as per ADA specification 19. Under dry condition the impression material satisfactorily replicated the detail 100% of the time. Under moist condition, only 58% of the impressions were judged satisfactorily.

With the present results it can be concluded that moisture caused a significant change on dimensional accuracy and detail reproduction of the hydrophilic polyvinyl siloxane impression material. However, further clinical trials are necessary to confirm the results of present study.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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