

Effect of heat sterilization and chemical method of sterilization on the polyvinyl siloxane impression material. A comparative study

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ABSTRACT

Background: Dental impression is a crucial part of the process of constructing a well-fitting prosthesis. In the clinical scenario, impressions can act as a vehicle for the transfer of bacteria and fungi. Therefore, an attempt was made to evaluate the dimensional accuracy of the newly introduced polyvinyl siloxane (PVS) impression material upon autoclaving and comparing it to the traditional means of chemical disinfection. **Materials and Methods:** A cross-sectional comparative *in vitro* study was conducted. Three groups were made for testing different sterilization methods. The sample size for the study was kept as 30 observations in each of the three groups. Test samples were prepared by making an impression of the die using the putty-wash technique. Statistical analysis was done by applying unpaired t-test, paired t-test, one-way analysis of variance (ANOVA) and *post hoc* Tukey's honestly significant difference (HSD). **Results:** Initial mean of samples of group I were compared to A (actual measurement of metal ruled block = 24.960), a dimensional change of 1.6% was found. Similarly, in group II, a change of 1.59% was found and in group III the change was 1.7%. There was mean shrinkage of 24.557 mm in group I, 24.586 mm in group II, and 24.535 mm in group III and these changes were found statistically significant. **Conclusion:** Dimensional changes in the impression material after disinfection with 2% glutaraldehyde were considered high compared to autoclaving and, hence, it may not be advisable to disinfect this material with 2% glutaraldehyde.

Keywords: Impression material, polyvinyl siloxanes, sterilization

Introduction

In prosthodontics, the dental impression is a crucial part of the process of constructing a well-fitting prosthesis and it is imperative that it copies the exact topography of the recorded site and translates it accurately to its cast. To achieve this, the impression material must

be both accurate and stable.^[1] Accuracy refers to the reproduction of the fine details of the imprinted area and depends on parameters of the fluid, unset material such as viscosity, pseudo-plasticity, and wettability. Another part relates to the transfer of the dimensions of the original shape and is influenced by events occurring during setting and removal such as polymerization contraction, thermal contraction, and elastic recovery.^[2,3]

The need for a more stable and accurate elastic impression material triggered the introduction and development of

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elastomers in Dentistry in the 1960s in Germany. Elastomers are synthetic rubber-based materials previously known as rubber impression materials but now more commonly referred to as nonaqueous elastomeric impression materials.

Polyvinyl siloxanes (PVS) are currently considered to reproduce the greatest detail of all the impression materials. The accuracy of impression material is dependent on its dimensional stability. PVSs show the smallest dimensional changes on the setting of all the elastomeric impression materials. The majority of this shrinkage is due to continued polymerization occurring within the first 3 min of removal of the impression from the mouth. Reductions in volume as low as 0.1 to 0.05% due to polymerization have been reported.^[4]

In the clinical scenario, impressions can act as a vehicle for the transfer of bacteria and fungi. Microorganisms can survive on, or even, inside the impressions.^[5,6] Even though their number decreases rapidly after rinsing with water perhaps to a practically harmless level, it has been shown that measurable bacterial load remains on impressions and can be transferred to casts.^[6-8] Therefore, the effort to eliminate as many potential risks as possible seems logical and mandatory.

A number of methods for the disinfection of impressions have been investigated and recommended including antimicrobial immersion system and/or spraying and then sealing in a bag or spraying with a HydroJet system.^[9] It has been suggested that the immersion system is better than spraying as the latter leads to the pooling effect and its effect is localized. Irreversible hydrocolloids tend to imbibe saliva and blood so the immersion system is preferable as it assures coverage of all the surfaces of the impression. However, these procedures may ensure only disinfection and not sterilization.^[10]

Although autoclaving is the most effective method of sterilization, autoclaving impressions could not be successfully done until recently in 2009, when an autoclavable PVS impression material was launched. However, there are only a few studies on the effect of autoclaving on the dimensional accuracy of that material in the literature. Claims have been made that the said material can be steam-autoclaved at 134°C without adverse effects to its dimensional stability or tear strength.

In light of these facts, a study was planned to evaluate the dimensional accuracy of the newly introduced PVS impression material upon autoclaving and comparing it to the traditional means of chemical disinfection.

Materials and Method

A cross-sectional, comparative, *in-vitro* study was conducted at the department of prosthodontics in a dental college. Three groups were made for testing different sterilization methods.

The sample size for the study was kept as 30 observations in each of the three groups. Therefore, a total of 90 test samples were prepared. The samples were divided into three groups of 30 impressions in each group:

Group (I): Group to be autoclaved,

Group (II): Group to be immersed in disinfectant with 2% of glutaraldehyde,

Group (III): Control group.

Method of data collection

Test samples were prepared by making an impression of the die using the putty-wash technique. Before making the impressions, the metal die was conditioned in a water bath at $32 \pm 1^\circ\text{C}$ for 1 h for simulating the intraoral conditions. An impression of the superior surface of a metal die (AA) was made using a mold (BB) with a putty-wash technique in two stages.

Testing procedure

Treatment of samples

In group 1, autoclaving for 15 min at 121°C and 12 psi, immediately after initial measurement was done. In group 2, disinfection by immersion in 2% glutaraldehyde for 30 min, immediately after initial measurement was done, and group 3 was left untreated for 24 h. Initial measurement was done immediately after preparing the sample and final measurement was done after 24 h of subsequent sterilization procedures.

All physical tests were performed in an air-conditioned laboratory at a temperature of 23°C ($\pm 1^\circ\text{C}$) and relative humidity of 50% ($\pm 5\%$).

Measurement procedure

Measurements were done using a traveling stage microscope (NIKON profile projector).

To calculate dimensional accuracy following recordings were done

1. Measurement on the ruled test block—A
2. Measurement of the test sample pre-treatment—B1
3. Measurement of the test sample post-treatment—B2

Statistical analysis was done by applying unpaired t-test. Within-group comparisons (i.e. between initial and final measurements of the samples) were done by applying a paired t-test. Between the groups' comparison, for more than two groups were done by using one-way analysis of variance (ANOVA) and post hoc Tukey's honestly significant difference (HSD). "*P*" value less than 0.05 was taken as significant. MEDCALC 4.0.0 version was used for all statistical calculations.

Results

Table 1 shows, linear dimensional change (mm) of the impression material in samples of group I. It is evident from the table that

there was a mean linear shrinkage indicated by the reduction in the distance between inner edges of cd and c'd' from 24.96 to 24.56 which is found statistically significant ($P < 0.001$).

Table 2 shows, linear dimensional change (mm) of the impression material in samples of group II. It is evident from the table that there was a mean linear shrinkage indicated by the reduction in the distance between inner edges of cd and c'd' from 24.96 to 24.59 which is found statistically significant ($P < 0.001$).

Table 3 shows, linear dimensional change (mm) of the impression material in samples of group III. It is evident from the table that there was a mean linear shrinkage indicated by the reduction in the distance between inner edges of cd and c'd' from 24.96 to 24.53, which is found statistically significant ($P < 0.001$).

It is evident from Table 4 that at baseline there was mean shrinkage of 24.557 mm in group I, 24.586 mm in group II, and 24.535 mm in group III. On the application of the one-way ANOVA test, these changes were found significant. When *post hoc* Tukey's HSD was applied, it was found that all the groups differed from each other and statistically significant.

Table 5 shows a mean length change in all three groups indicative of a positive shrinkage. It is evident from this table that there was mean shrinkage of 0.291 mm in group I, a higher mean shrinkage of 0.424 mm in group II, and an even higher mean shrinkage of 0.434 in group III. These changes were found significant in the application of the one-way ANOVA test. When *post hoc* Tukey's HSD was applied, it was found that change in group I was significantly different from group I and group II while the change in group II and group III were similar.

Table 6 shows that there was an overall shrinkage (dimensional change percentage) at 24 h seen in the samples of group I, indicated by the reduction in the dimensional change (%) from 1.61 to 1.45, which was statistically not significant.

Table 7 shows that there was an increase in (dimensional change percentage) at 24 h seen in the samples of group II, indicated by the increase in the percentage dimensional change from 1.596 to 1.762 and this change is statistically very highly significant as " P " value = 0.000 or < 0.001 .

Table 8 shows that there was an increase in (dimensional change percentage) at 24 h seen in the samples of group III, indicated by the increase in the percentage dimensional change from 1.707 to 1.746 and this change is statistically mildly significant as " P " value = 0.045.

It is evident from Table 9 that on the application of a one-way ANOVA test the dimensional changes were found to be significant. When *post hoc* Tukey's HSD was applied it was found that change in group I was significantly different from group II and group III but, change in group II was not significantly higher than group III.

Table 1: Mean length change (mm) between group I and ruled block

Group	n	Mean	Standard deviation	Mean difference	t	P*
Ruled block-A	3	24.96	0.001193	0.403	20.237	0.000
Group I- B1	30	24.56	0.034			

*Unpaired t-test

Table 2: Mean length change (mm) between group II and ruled block

Group	n	Mean	Standard deviation	Mean difference	t	P*
Ruled block-A	3	24.96	0.001193	0.374	21.285	0.000
Group II-B1	30	24.59	0.03			

*Unpaired t-test

Table 3: Mean length change (mm) between group III and ruled block

Group	n	Mean	Standard deviation	Mean difference	t	P*
Ruled block-A	3	24.96	0.001193	0.425	45.345	0.000
Group III-B1	30	24.53	0.016			

*Unpaired t-test

Table 4: Comparison of initial mean length change (mm) between all three groups

Parameter	Group	n	Mean	Std. deviation	ANOVA		P* <0.05 from	
					F	P		
B1	I	30	24.557	0.034	25.281	0.000	II, III	
	II	30	24.586	0.030				I, III
	III	30	24.535	0.016				I, II

*Post hoc Tukey's honestly significant difference (HSD)

Table 5: Comparison of mean length difference of all samples and ruled block after 24 h between all three groups

Parameter	Group	n	Mean	Standard deviation	ANOVA		P* <0.05 from	
					F	P		
A-B2	I	30	0.291	0.123	35.904	0.000	II, III	
	II	30	0.424	0.023				I
	III	30	0.434	0.017				I

*Post hoc Tukey's HSD ANOVA: analysis of variance

Table 6: Linear dimensional change (%) in group I

		Mean	Standard deviation	Mean difference	t	P*
Autoclaving	B1	1.612	0.1388	0.161	1.731	0.094
	B2	1.451	0.4574			

*Paired t-test (+) positive value suggests that there has been a decrease in % of dimensional change seen in the samples at B2 time interval when compared with B1 time interval.

Discussion

The results of the present study were statistically analyzed and it was found that initial measurements of samples in all the groups were statistically and significantly different. It might be due to

Table 7: Linear dimensional change (%) in group II

	Mean	Standard deviation	Mean difference	t	P*
Disinfection B1	1.596	0.1451	-0.1657	-7.821	0.000
B2	1.762	0.1224			

*Paired t-test (-) negative value suggests that there has been an increase in % of dimensional change seen in the samples at B2 time interval when compared with B1 time interval.

Table 8: Linear dimensional change (%) in Group III

	Mean	Standard deviation	Mean difference	t	P*
Control B1	1.707	0.09244	-0.03867	-2.093	0.045
B2	1.746	0.09427			

(-) negative value suggests that there has been an increase in % of dimensional change seen in the samples at B2 time interval when compared with B1 time interval.

Table 9: Comparison of mean difference in 24 h in three groups

Group	n	Mean	Standard Deviation	ANOVA		P* < 0.05 from
				F	P	
I	30	0.1617	0.50986	8.632	0.000	II, III
II	30	-0.1653	0.11596			I
III	30	-0.0387	0.10009			I

*Tukey HSD(-) negative value suggests that there has been an increase in % of dimensional change seen in the samples at B2 time interval when compared with B1 time interval.

the fact that it was not possible to make all 90 impressions at the same time and then randomize them into three groups. Also with time, the material is likely to show some changes in linear measurements. To control the film thickness of the light body impression material, a polythene spacer sheet was used in the study to prevent it as an influencing factor. Impression making in the clinical situation will never give exactly a similar impression if an impression is repeated in the same patient, therefore, this difference may not be clinically significant.

When the initial mean of samples of group 1 was compared to A (actual measurement of metal ruled block = 24.960), a dimensional change of 1.6% was found. Similarly, in group II change of 1.59% was found and in group III the change was 1.7%. This change can also be explained from the fact that maximum dimensional change occurs in the first 24 h of impression making and maximum occurs in the first 1 h of making the impression. According to McCabe, a linear dimensional change up to 1.5% at the end of 24 h is acceptable for all consistencies of the PVS impression material.^[1]

Nimonkar *et al.* conducted a study to evaluate the effect of chemical disinfectants and ultraviolet (UV) disinfection on the dimensional stability of the PVS impressions and found significant dimensional changes in samples disinfected with 2% glutaraldehyde and 1% sodium hypochlorite when compared with the samples disinfected using UV disinfectant unit.^[11]

Reddy *et al.* in a study subjected samples to long cycle autoclaving (134°C for 18 min) and poured type IV stone casts. They recommended autoclavable PVS material for making

short-span multiunit restorations rather than when planning for a complete arch full restorations. In comparison to the previous study, interestingly from our testing, it was noted that after 24 h the autoclaved samples showed a mean length change (shrinkage) of 291 μm but this could be due to initial difference in mean length.^[12] Tjan stated that in an autoclaved PVS impression, a change of approximately 50 μm was acceptable. So, if we neglect the change of length, which may have occurred due to the limitations of this study, the impression with the group I is the most suitable for preparing final prosthetic restorations over the casts poured at 24 h of autoclaving.^[13] Surendra *et al.* studied the effect of autoclaving on the dimensional accuracy of a PVS (Affinis) impression material revealed that there was higher mean dimensional change immediately after autoclaving when compared to the other two time intervals, that is, before autoclaving and 24 h after autoclaving.^[4]

According to Anusavice,^[4] at the end of 24 h, the contraction should not exceed 0.5% for PVS elastomers. The additional silicones have the smallest dimensional change on the setting of about -0.15%. Permitted maximum dimensional change at 24 h is 1.5% for all consistencies. In this study, a dimensional change of 1.45% was seen which is within the recommended range.

In this study, on disinfection Affinis PVS impression (for 30 min using 2% alkaline glutaraldehyde) showed changes in dimensions with the mean difference being negative, which meant that shrinkage continues to occur after the immersion and had a larger significant effect on the dimensional accuracy. The value of "P" to be near 0.05 is statistically a highly significant shrinkage.

Mahalakshmi *et al.* evaluated the effect of chemical disinfectants on the surface detail reproduction, dimensional stability, and surface texture of PVS impressions and concluded that 2% glutaraldehyde and electrolyzed oxidizing water (alkali) resulted in statistically insignificant dimensional change, while 1% sodium hypochlorite, electrolyzed oxidizing water (acidic), and electrolyzed oxidizing water (neutral) have resulted in statistically significant dimensional changes. All the test disinfectants except 1% sodium hypochlorite showed a reduction in surface roughness (Ra) values.^[14]

In a study, Bergman *et al.* reported a dimensional change in elastomers on immersing with 2% glutaraldehyde for 1 hour ranging from 0.16% to 0.31%. They concluded that this change would increase the marginal length of a typical crown by 15 μm .^[15] In group II disinfected samples, there was a continuous shrinkage when values changed from A—24.96 mm to B1—24.59 mm and 24 h later showed a value of 24.53 mm. Therefore, a net 1.76% dimensional change occurred at B2 in this group and it was considered to be a highly significant shrinkage (allowed < 1.5%) of the material with a mean length change of 0.424 mm from the initial metal die value. In group III, samples showed as shrinkage of 1.74% with a mean length change of 0.434 mm. Thus, it may not be advisable to pour Affinis impressions without autoclaving. As a rule, this material is best autoclaved and poured after 24 h to

gain compensatory expansion. As both groups II and III showed significant shrinkage, group III behaved more like group II.

As related to dimensional changes on disinfection, Toh *et al.*^[16] found that PVS after a 30-minute immersion in iodophor or glutaraldehyde had shown small changes, whereas, Merchant *et al.* noted no change.^[17] Several studies analyzed dimensional stability and detail reproduction of PVS impression material immersed from 10 to 60 min in 2% glutaraldehyde, sodium hypochlorite, or phenol solutions.^[18,19] The results of these studies revealed that PVS was dimensionally stable after disinfection. Nevertheless, Minagi *et al.* found that immersion of PVS in sodium hypochlorite or 2% glutaraldehyde for more than 60 min affected linear dimensions and detail reproduction.^[19]

The results of the present study show that the most acceptable values have been seen in autoclaving group I. Further *in-vivo* and *in-vitro* studies are required to substantiate the physical properties of this material as adequate so that it can be widely accepted in clinical practice. Future research work may be done to test surface reproduction, wet ability, tear strength, and other physical properties for all consistencies of this impression material.

Implications for clinical practice

The issue regarding cross-infection in dental clinics and hospital steps is a major concern for the dentist. Impression making is an important aspect of fabricating prostheses. Impressions carry different microorganisms as it comes in contact with saliva and blood in the oral cavity. There are various methods used to disinfect the impression materials but these conventional strategies present several disadvantages. After disinfection, it is important that impressions remain accurate and stable in reproducing the oral structures. The application of proper disinfection methods after impression making nowadays prevent the cross-infection in dental setups and hence this must be made mandatory in daily practice.^[11,20,21]

Conclusion

It was concluded that linear dimensional changes in the impression material tested after autoclaving are all within the recommended ranges, and hence this impression material may be acceptable clinically for fabricating short-span fixed dental prosthesis (FPDs). Pouring impressions after autoclaving must be delayed for at least 24 h to take advantage of the rebound phenomenon showed by this material. Dimensional changes in the impression material after disinfection with 2% glutaraldehyde were considered high compared to autoclaving, and hence, it may not be advisable to disinfect this material with 2% glutaraldehyde. The control group showed similar dimensional changes as disinfection. Hence, this material may necessarily need autoclaving before pouring it in stone.

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Conflicts of interest

There are no conflicts of interest.

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