ORIGINAL RESEARCH

Comparative Evaluation of Dimensional Stability of Elastomeric Impression Materials Subjected to Ultraviolet Irradiation and Spray Atomized Disinfection: An *In Vitro* Study

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Abstract

Aim and background: The study was done to compare and evaluate the linear dimensional stability of three elastomeric impression materials, namely polyether (PE), polyvinyl siloxane (PVS), and polydimethylsiloxane (PDS) after subjecting to ultraviolet (UV) irradiation and spray disinfection techniques.

Methods and methodology: Three elastomeric impression materials namely PE (3M ESPE Impregum soft), PVS (Zhermack elite P And P), and PDS (Zhermack Oranwash L and its indurater) of light body consistency were used. Ultraviolet rays and 2.5% chlorhexidine (CHX) gluconate (spray disinfection) were used as disinfectants. A master die was used to create 40 samples from each material. Three parallel lines of equal length were given in the die. A sample was accepted if two or three lines were reproduced continuously and were well-defined. A total of 120 samples were made and subjected to disinfection. Out of the 40 samples from each material, 20 samples were irradiated with UV light of approximately 200–280 nm for 20 minutes and the next 20 from each material were treated with spray atomized disinfection. The sample was sprayed and sealed in a plastic bag for 30 minutes. Measurements of the samples were done. Each line in the sample was evaluated under a stereomicroscope at 10× magnification. The average length of lines in each sample was compared to that in the die. The values obtained in the UV irradiation and spray disinfection were also compared.

Results: A statistically significant difference was shown in the dimensional stability of all three elastomeric impression materials subjected to UV irradiation and spray disinfection when compared with that of the die. Polyether demonstrated a statistically significant difference when compared with UV and spray atomized samples whereas PVS and PDS showed dimensional change when compared with the die, but no statistically significant difference was found when samples treated with both the disinfection techniques were compared.

Conclusion: Elastomeric impression materials of light body consistency had dimensional change when treated with UV irradiation for 20 minutes and spray atomization with 2.5% CHX gluconate.

Clinical significance: Prevention of cross-contamination when handling impression materials without hampering their dimensional stability is mandatory to obtain a successful treatment.

Keywords: 2.5% chlorhexidine gluconate, Condensation silicone, Disinfection, Elastomeric impression materials, Polyether, Polyvinyl siloxane, Spray atomization, UV irradiation.

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Introduction

Sterilization and disinfection are crucial to prevent infectious organisms from cross-contaminating patients and dental professionals.[1] The process of sterilization, which can be carried out chemically or physically, removes or eradicates all microbiological life. Disinfection is the term used to describe a procedure on inanimate things that removes most or all pathogenic germs, except bacterial spores.[2]

Chemical sterilants are substances used to eliminate microbiological life in all its forms. High-level disinfectants eliminate all germs except bacterial spores, in a shorter amount of time. The majority of vegetative bacteria can be killed by low-level disinfectants, but only some fungi and viruses can be killed in a reasonable amount of time (≤10 minutes). Generally, mycobacteria, vegetative bacteria, viruses, and most fungi can all be killed by intermediate-level disinfectants; however, bacterial spores are not always destroyed. Germicides vary significantly, mainly in the range of antibiotics they can combat and how quickly they work.[3]

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Cross-contamination of infectious diseases through dental equipment puts dental professionals at high risk of being exposed to diseases such as AIDS, Hepatitis, etc. As the impression comes into contact with blood and saliva, there is a high probability that microorganisms will be transferred from the patient to the dental professional. Thoroughly washing under running water is advised, but it does not ensure that all microbes have been eliminated. According to reports, washing the impression materials with water alone only eliminates 40% of the microorganisms.[4] Strict guidelines for disinfection of all dental instruments and materials have been proposed by the American Dental Association (ADA). Following a thorough rinsing to eliminate blood, saliva, and food particles, all dental impressions should be disinfected with glutaraldehyde, sodium hypochlorite, iodophor, or phenol, as per the ADA's requirements.[2]

Most pathogenic organisms can be eliminated through chemical disinfection but spores can still be present in the impression. To kill the spores, other sterilization methods such as steam autoclave or ethylene oxide gas autoclave and radiofrequency glow discharging and UV irradiation can also be done.[5]

Elastomeric impression materials are being used widely for recording impressions from the patient in almost all types of cases. These rubber-based impression materials are known for their better stability and accuracy compared to irreversible hydrocolloids. However, it is imperative to disinfect the impression after removing it from the patient's mouth despite the material that is being chosen. As mentioned earlier, ADA has specified certain disinfection protocols to prevent cross-contamination from the patient. The accuracy and dimensional stability of the employed impression material can be impacted by these disinfection procedures and materials. Alterations in stability can lead to the fabrication of faulty restorations. In order to effectively disinfect and preserve the physical qualities of the impression material, it is imperative to understand which disinfecting material and technique are superior.

Polyvinyl siloxane, PDS, PE, and polysulfide are rubber-based impression materials that are being used for recording impressions. The main factors influencing disinfection protocols for elastomeric impression materials are the hydrophilicity of these rubber-based materials, their tolerance to immersion in water or other fluids, and the effect of surfactants. This can be attributed to the different physical properties of each material.

Certain studies found that elastomeric impression materials have better dimensional stability and tear strength than hydrocolloids.[6] The present study is done to compare the dimensional stability of PVS, PE, and PDS impression material after UV irradiation and spray atomization.

Methods and Methodology

Three elastomeric impression materials namely PE (3M ESPE Impregum soft), PVS (Zhermack elite P And P), and PDS (Zhermack Oranwash L and its indurater) of light body consistency were used in the study. Ultraviolet rays and 2.5% Chlorhexidine (CHX) Gluconate (spray disinfection) were used as the disinfectants.

Preparation of Samples

Samples were made from a stainless steel die which was fabricated as recommended by ADA specification No. 19.[7] The stainless steel mold consists of a ruled block, mold, and a riser (Fig. 1). The ruled block has three parallel lines that are equal in length and two crosslines are also present to determine the dimensional stability. Forty samples were made from each material, out of which 20 samples were subjected to UV irradiation and the other 20 were subjected to spray atomization.

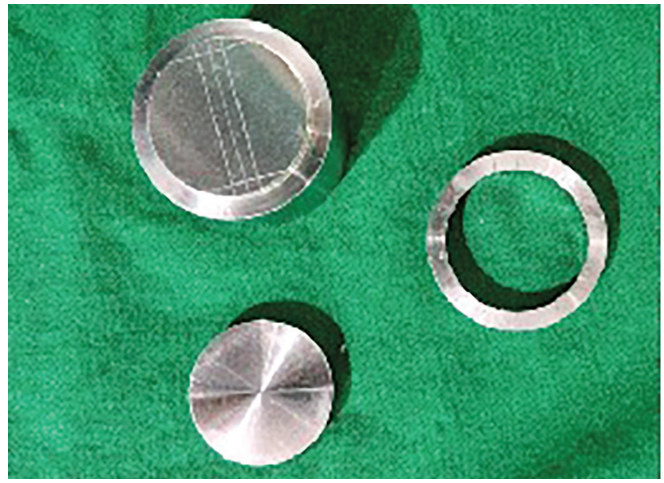

Fig. 1: Stainless steel mold manufactured according to ADA

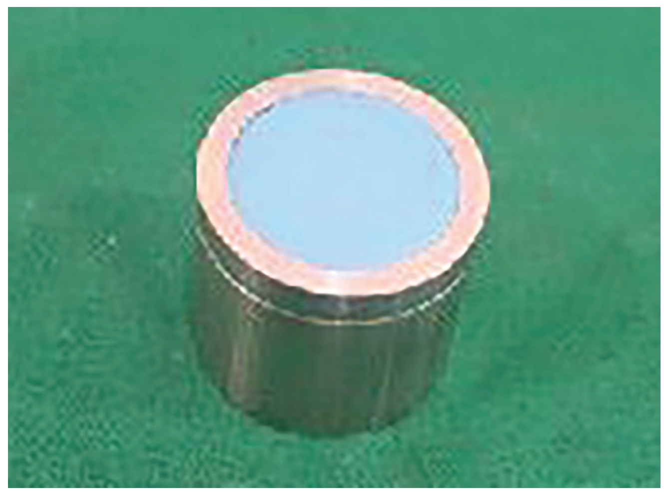

Fig. 2: Polyvinyl siloxane sample prepared from the stainless die

Group I: Impression Material Subjected to UV

Ia: PE subjected to UV irradiation (n = 20).

Ib: PVS subjected to UV irradiation (n = 20).

Ic: PDS subjected to UV irradiation (n = 20).

Group II: Impression Material Subjected to Spray Disinfection

IIa: PE subjected to spray disinfection (n = 20).

IIb: PVS subjected to spray disinfection (n = 20).

IIc: PDS subjected to spray disinfection (n = 20).

Manipulation of Polyvinyl Siloxane Light Body Material

The automixing gun is loaded with a cartridge and mixing tip. The material was dispensed from the syringe tip. A glass plate was kept over the die and a weight was placed over it and allowed to set as per the manufacturer's recommendation (Fig. 2).

Manipulation of Polyether Light Body Material

The base paste and catalyst paste were mixed in a mixing pad manually till a uniform color was obtained and transferred into the die. The die was then covered with a glass plate, and weight

Fig. 3: Condensation silicone- spray atomized

was retained for the designated setting time as suggested by the manufacturer.

Manipulation of Polydimethylsiloxane Light Body Material

The base paste and the indurent were mixed manually in a mixing pad till a uniform color was obtained and transferred into the die. A glass plate, followed by a weight, was placed on the die and allowed for setting up to the time recommended by the manufacturer.

Spray Atomization of Samples

Twenty samples from each material were subjected to spray atomization. Each sample was sprayed with CHX gluconate solution till complete wetting of all surfaces was done. It used a finger sprayer and a simple aperture nozzle to force the contents out of the container without the need for an external compressed air supply. Every disinfection solution was used from the same bottle. The samples were sprayed, then sealed in a plastic bag and left for half an hour. It was then washed in running water and air-dried (Fig. 3).

UV Irradiation of Samples

Twenty samples from each material were subjected to UV irradiation. Ultraviolet rays of wavelength 200–280 nm from a clinical UV chamber were used for 20 minutes for this purpose.

Observation in Stereomicroscope

All the prepared samples were observed under a stereomicroscope with 10× magnification. The lines that are reproduced from the die into the samples were carefully inspected. The measurement of the three lines from the crosslines was taken and the average of the three lines was calculated (Fig. 4).

The average measurement of the crosslines in the metal die was set at 25 mm and the mean percentage of change for each specimen was calculated using the following formula:

$$\partial L = (L1 - L2/L1)100$$

where $L1$ is the mean distance measured between crosslines on the test block and $L2$ is the mean distance measured between crossbones on the test specimen.

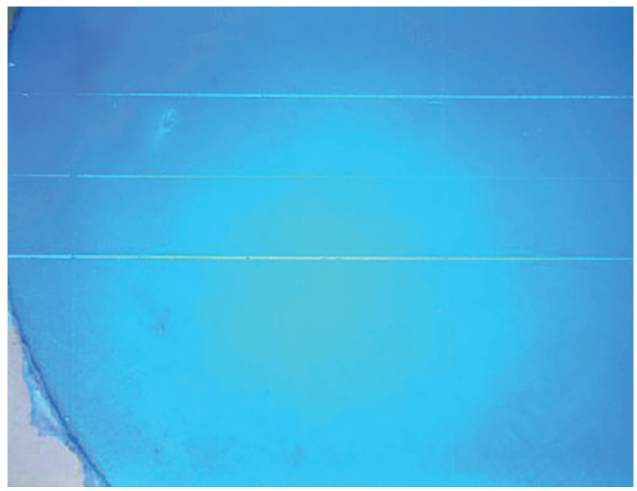

Fig. 4: Addition silicone samples observed through stereomicroscope

Results

Based on the values obtained, data analysis was done using MS Excel and IBM SPSS statistics. Detailed statistical analysis was conducted on the respective samples using the analysis of variance test (ANOVA).

Polyether Impression Material

Polyether light body consistency materials subjected to UV irradiation showed a statistically significance variation by ANOVA. The measurements were taken from the test samples and compared with that of the master die. Statistical analysis showed $p < 0.001$.

Polyether subjected to spray atomization also showed a statistically significant difference with $p = 0.000$. The mean values obtained from the test samples were compared with that of the master die. A comparison of UV irradiated and spray-atomized samples of PE impression material showed a statistically significance variation with a p-value less than 0.00 (Table 1).

Polyvinyl Siloxane Impression Material

Polyvinyl siloxane light body consistency material also showed a statistically significant difference after UV irradiation when compared with that of the master die by ANOVA. The value

Table 1: Comparison of UV irradiated and spray atomized samples of condensation silicone, polyether, and polyvinyl siloxane

		Group statistics								
	VAR00007	*N*	*Mean*	*Std. deviation*	*Std. error mean*					
VAR00012	UV radiated condensation silicone	20.00	23.49	0.08	0.02					
	Spray atomized condensation silicone	20.00	23.50	0.07	0.02					
		Independent samples test								
						t-test for equality of means				
		Levene's test for equality of variances				*95% confidence interval of the difference*				
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean difference*	*Std. error difference*	*Lower*	*Upper*
VAR00012	Equal variances assumed	1.939	0.172	−0.195	38	0.847	−0.00475	0.02439	−0.05413	0.04463
	Equal variances not assumed			−0.195	36.676	0.847	−0.00475	0.02439	−0.05418	0.04468
		Group statistics								
	VAR00007	*N*	*Mean*	*Std. deviation*	*Std. error mean*					
VAR00010	UV radiated polyether	20	23.9248	0.28952	0.06474					
	Spray atomized PE	20	23.6961	0.26075	0.05831					
		Independent samples test								
						t-test for equality of means				
		Levene's test for equality of variances				*95% confidence interval of the difference*				
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean difference*	*Std. error difference*	*Lower*	*Upper*
VAR00010	Equal variances assumed	0.003	0.958	2.624	38	0.012	0.22865	0.08712	0.05227	0.40503
	Equal variances not assumed			2.624	37.591	0.012	0.22865	0.08712	0.05221	0.40509
	VAR00007	*N*	*Mean*	*Std. deviation*	*Std. error mean*					
VAR00011	UV radiated PVS	20	23.4544	0.13373	0.0299					
	Spray atomized PVS	20	23.4186	0.15009	0.03356					
		Independent samples test								
						t-test for equality of means				
		Levene's test for equality of variances				*95% confidence interval of the difference*				
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean difference*	*Std. error difference*	*Lower*	*Upper*
VAR00011	Equal variances assumed	0.029	0.865	0.796	38	0.431	0.0358	0.04495	−0.0552	0.1268
	Equal variances not assumed			0.796	37.505	0.431	0.0358	0.04495	−0.05523	0.12683

$p = 0.000$ was obtained from the statistical analysis. Polyvinyl siloxane also showed a statistically significant difference after spray atomization. The p-value was found to be 0.000. Comparison of UV irradiated and spray-atomized samples of PVS impression material showed no statistically significance variation with a p-value of more than 0.00 (Table 1).

Condensation Silicone

Condensation silicone light body material also showed a statistically significant difference after UV irradiation. Analysis of variance test analysis showed $p = 0.00$. When subjected to spray atomization, no statistically significant difference was observed between the test samples from that of the master die. Condensation silicone materials subjected to UV irradiation and spray atomization were also compared statistically and no significant differences were found in comparison between the two techniques (Table 1).

Discussion

Rubber-based impression materials are commonly used for making an impression in fixed partial denture cases. These impression materials are appropriate for recording prepared abutments and the associated margins due to their accuracy and dimensional stability. Samaranayake et al.[8] observed that *Streptococcus mutans, Staphylococcus aureus, Escherichia coli, and Candida albicans* are found in the impression after removal from the mouth. Additionally, they have found that dentate individuals have a considerably higher microbial load on impression materials than edentulous patients.

Most of the researches are done to analyze the dimensional stability of regular consistency impression material after disinfection. The current study aims to evaluate and compare the dimensional stability of light body impression material after UV irradiation and spray atomization.

Ultraviolet rays of wavelength between 200 and 280 nm kill pathogenic bacteria, bacterial spores, and potential viruses. Subjecting the elastomeric impression material to UV radiation showed a significant dimensional change in all three elastomeric materials in the present study. The highest change was seen in addition silicone compared to condensation silicone and PE, and also the least change was seen in PE. These findings reject the null hypothesis as there is a change in the dimensional stability of elastomeric impression material when exposed to UV irradiation. The specimens were kept under UV rays for 15 minutes.

Aeran et al.[4] had recommended the use of dental UV chambers for disinfecting elastomeric impression materials and alginate. The study was done to evaluate the efficacy of the dental UV chamber in disinfecting the impression material and was found to be effective in decreasing bacterial colonies. The period for which the impression materials were exposed was also crucial in the study. For alginate, disinfection was obtained on UV ray exposure for 10 minutes whereas in the case of addition silicone, no microbial growth was present on exposure to UV radiation for a time interval of 10 minutes. Disinfection was completely attained on exposure for 3 minutes to UV radiation in the case of PE impression material. Polyzois et al.[9] recommended the use of microwave irradiation of impression materials. They found that there was a dimensional change after microwave irradiation but it was only 0.005–0.009%. In the present study, all the impression materials were exposed to UV rays for 15 minutes. The change in dimensional stability could be due to prolonged exposure to UV rays. In all the previous studies putty or monophase consistency was used to analyze the dimensional stability. Ultraviolet irradiation of PVS monophase consistency did not show any dimensional instability in a research conducted by Maru et al.[10] Ultraviolet rays of 258 nm for 12 minutes were used in that study.

Chemical disinfection is the most accepted method for disinfecting impression materials. According to the ADA Council on Dental Therapeutics,[2] 32 brands of commercial products are recognized as being effective disinfecting or sterilizing agents for use in dentistry. Tuller et al. observed no clinically significant dimensional changes with disinfection using 2% glutaraldehyde.[11] The most commonly recommended methods involve immersing or spraying impression materials in a disinfection solution for varying durations of time after cleaning them of blood and saliva. Katyayan et al. and Walker et al. analyzed that dimensional changes of elastomer were within ADA specification after disinfection with phenol and 0.5% sodium hypochlorite.[12,13]

Immersion is the method most recommended. However, studies done by Da Silva and Salvador,[14] Drennon et al.,[15] Matyas et al.,[16] and Gounder and Vikas,[1] have shown that spray atomization can be used as an alternative to immersion technique. The immersion technique tends to cause dimensional change due to the absorption of the disinfectant into the material, this effect can be negated by the spray atomization technique.

In the present study, all three impression materials were chemically disinfected using a spray atomization technique with 2.5% CHX gluconate. Chemically CHX is made up of two symmetric 4-chlorophenyl rings and two biguanide groups connected by a central hexamethylene chain.[5] Chlorhexidine acts by the interaction of positively charged molecules and negatively charged phosphate groups on the microbial wall. There were significant changes in all three materials subjected to CHX gluconate spray atomization. The materials were exposed to the disinfectant for 30 minutes and then rinsed in running water and air-dried.

According to many authors, PVS has proved to have the least dimensional change compared to PE and condensation silicone. Gounder and Vikas found that the dimensional change of addition silicone material with disinfection in 0.5% CHX gluconate using spray atomization was clinically acceptable. However, the addition silicone showed dimensional change with time when disinfected for a longer time. They suggest that it could be due to the presence of surfactants, which are added to increase reproducibility that affected the dimensional change. This agrees with the present study in which dimensional change was observed with CHX gluconate disinfection. However, studies done by Matyas et al.[16] showed that either the spray or immersion technique will not significantly affect the dimensional stability of the cast, this proves that despite the technique the concentration of the disinfectant and the period to which it is exposed to the impression plays a key role in the dimension. Keyf[17] observed that condensation silicone has more shrinkage on the setting than other rubber-based impression materials. This could also be attributed to the change in dimensional stability of the impression, in addition to the disinfection of the material. Changes in the dimension of elastomeric impression materials were also reported by Ivaniš et al.[18] when treated with 0.5% CHX gluconate. Polyether showed a significant difference when the UV-irradiated and spray-atomized samples were compared. Spray atomized samples showed more dimensional change compared to those subjected to the UV irradiated one. In the present study, PE showed more dimensional change on spray atomization compared to UV irradiation.

But, addition silicone and condensation silicone showed no statistically significant difference when compared among the disinfection techniques. This agrees with the findings of Ivaniš et al. and Gounder and Vikas, in which PE subjected to chemical disinfection either by spray or immersion undergoes dimensional change, and the former author concluded that PE should not be disinfected with 0.5% CHX gluconate using spray atomization as it caused a significant change in the dimension. However, the disinfectant used in their study was sodium hypochlorite done by spray atomization technique. Yilmaz et al.[19] studied the effect of disinfection on the dimensional stability of three PE impression materials used for mono phase technique and found that there was a statistically significant difference among the three groups. The disinfectant used in their study was sodium hypochlorite and 2% glutaraldehyde, but this finding contradicts Rowe and Forrest, who observed that silicones and PE immersed in CHX gluconate 0.5% for 30 seconds, 1 minute, and 24 hours showed no significant dimensional difference between the treated and untreated ones. On comparing the changes that occurred between the UV-irradiated and spray-atomized PE samples, there was a statistically significant difference. There was a statistically significant difference when comparing both UV-disinfected samples and Spray atomized samples with that of stainless steel die. More dimensional change was seen in CHX-treated PE samples compared to UV-irradiated ones. Whereas when PVS and condensation silicone samples were compared among the UV irradiated and CHX treated one, no statistically significant differences were found, but there was a statistically significant difference when compared with that of the measurements from the mold. The dimensional change in all three elastomeric impression materials in the present study could be due to exposure to a higher concentration of CHX gluconate 2.5% in 70% alcohol for 30 minutes. Polymerization shrinkage can also be a cause for the dimensional change in the present study along with the effect of the disinfectant. Many authors found that the presence of alcohol had caused a dimensional change in irreversible hydrocolloids but have not found any correlation with elastomeric impression material.

Conclusion

The objective of the study was to evaluate the change in dimension of PE, PVS (addition silicone), and condensation silicone subjected to UV irradiation and spray disinfection and to compare the dimensional changes that have occurred in both the disinfecting procedures.

Within the limitation of the present study following conclusions can be drawn:

- Polyether light body impression material had shown a dimensional change in both UV irradiation and spray atomization. There was also a statistically significant difference when both the impression techniques were compared.
- Polyvinyl siloxane light body impression material had shown dimensional change when subjected to UV irradiation and spray atomization, but there was no statistically significant difference when both the disinfection techniques were compared.
- Condensation silicone light body impression material had also shown dimensional change when subjected to UV irradiation and spray atomization, however, condensation silicone also did not show any statistically significant difference when compared among the disinfecting techniques.

Further studies are required to analyze which light body impression material has more dimensional change when subjected to disinfection.

Clinical Significance

Impression materials must be thoroughly disinfected to prevent cross-contamination. But chances of altering the impression properties when in contact with disinfectant must be considered as it may hamper the outcome of the treatment.

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